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The Multiple Benefits of Measures to Improve Energy Efficiency
A Summary Report

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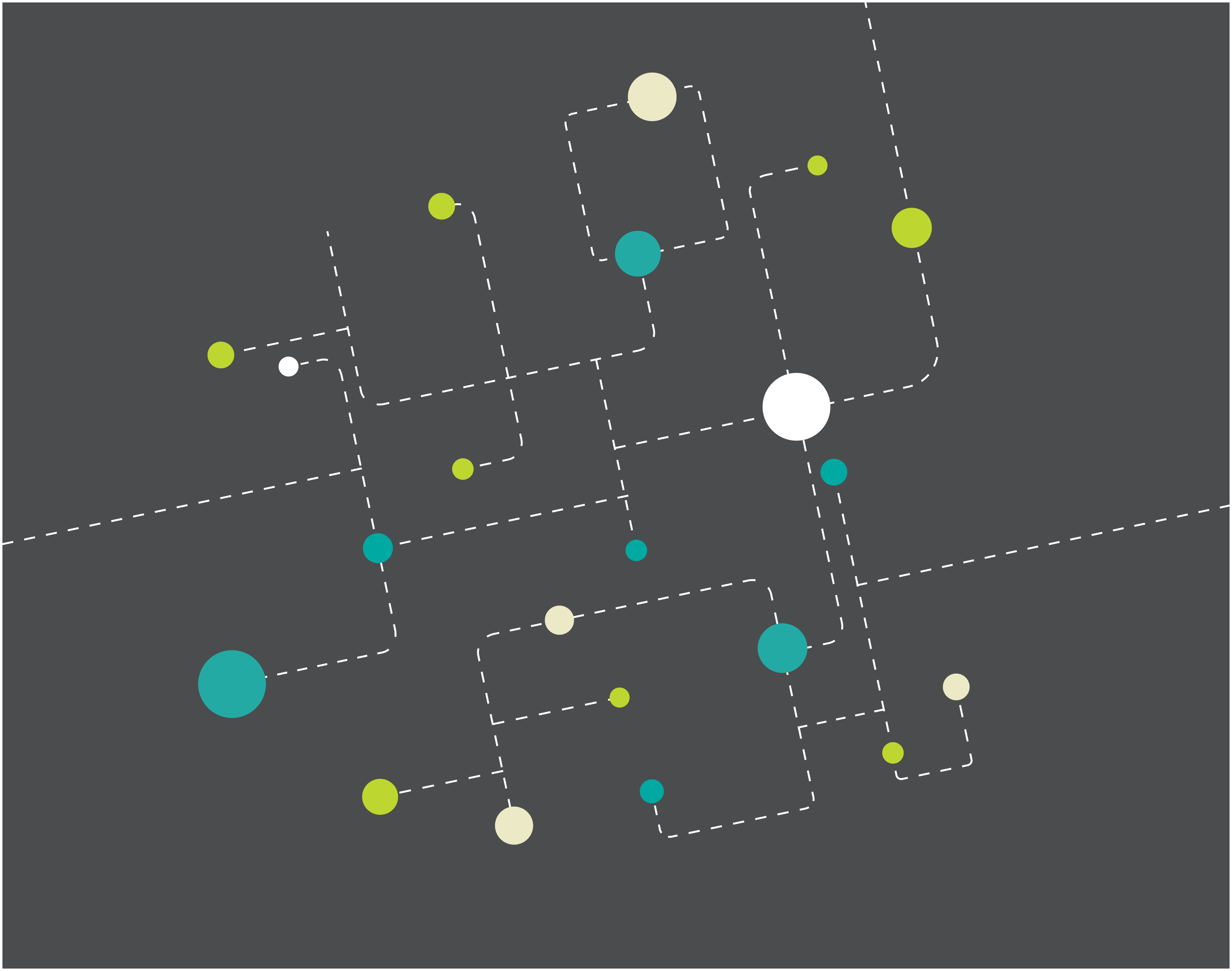

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THE MULTIPLE BENEFITS OF MEASURES TO IMPROVE ENERGY EFFICIENCY

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THE MULTIPLE BENEFITS OF MEASURES TO IMPROVE ENERGY EFFICIENCY

A SUMMARY REPORT

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The findings, interpretations and conclusions presented in this report are the author's alone and should not be attributed to UNEP DTU Partnership.

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EXECUTIVE SUMMARY

Energy efficiency has been aptly dubbed 'the first fuel': it is widely available, it represents a cost effective investment and it increases competitiveness. Not least, improvements in energy efficiency can bring about other positive economic, social and environmental impacts, such as enhanced energy security, increased job creation, decreased greenhouse gas emissions, and reduced air pollution, both locally and globally.

Yet, the promise of such positive impacts has not generally been enough to spur more widespread improvements in energy efficiency, at least not to the degree that the breadth of these impacts might suggest. Experience shows that price stimuli alone cannot unlock the full potential of energy efficiency: a complex mix of market and behavioural determinants hinders the adoption of more efficient technologies in ways that are not fully understood.

Understanding the barriers to, and enablers for, energy efficiency requires targeted information and analysis. This report is a summary of four detailed studies providing new insights on how to promote efficiency in selected priority areas. It complements initiatives such as the so-called energy efficiency accelerators, which seek to increase the uptake of selected technologies, as well as the work of many other institutions committed to improving energy efficiency.

This report is being released at a critical time in the climate change negotiations, as parties to the United Nations Framework Convention on Climate Change submit their so-called intended nationally determined contributions, in the lead-up to the conference of the parties to the convention, in Paris, in December 2015. These 'contributions' will shape the level of ambition of the new climate change agreement that the conference is expected to achieve. As parties update and renew their 'contributions' to the agreement, they will have to rely on all available mitigation options, with energy efficiency being a critical option.

The modelling estimates and the case studies presented in this report illustrate that, while significant progress has already been achieved, the case for accelerating energy efficiency action is strong. Key highlights include:

- At the global level, energy efficiency improvements would account for between 2.6 and 3.3 Gt CO_2e of the reductions in 2030, equivalent to between 23 and 26 percent of the overall reductions achieved in a scenario where the price of carbon dioxide equivalents was USD 70 per tonne.
- In absolute terms, the energy supply and industry sectors show the highest reductions in greenhouse gas emissions attributable to energy efficiency. In relative terms, it is the transport sector that shows the highest levels of emission reductions.
- The three mitigation scenarios considered suggest that the higher the carbon price, the greater the energy savings, and the larger the economic growth and employment benefits.
- While G20 countries account for about 90 percent of total emission reductions in the three mitigation scenarios, all countries can gain considerable benefits from improving the way they transform, distribute and use energy.

Survey results from the case studies in this report highlight the types of benefits that energy efficiency programmes can deliver, from mitigation of greenhouse gas emissions and increased energy access, to reduced public sector spending and improvements in human health and well-being, among others.

The following examples are given for illustrative purposes:

- **Energy savings and greenhouse gas emission reductions.** Germany's building efficiency programme resulted in energy savings of 2,200 GWh in the period between 2008 and 2010, and avoided 0.8 Mt CO_2e in 2012. For comparison, these energy savings are equivalent to the electricity used annually by about 650,000 households in Germany.
- **Economic growth, trade balances and energy prices.** A demand-side management programme in Vietnam resulted in additional investment of USD 5.2 million between 2004 and 2010.
- **Increased access to energy and reduced fuel poverty.** Fuel poverty was prioritised in Peru's revised policy framework, which led to the replacement of 30,000 inefficient heaters by 2011.

While the benefits of energy efficiency are substantial, they can be difficult to quantify. For example, even though job creation is often recognised as a positive impact of energy efficiency programmes, the actual scale of the impact is seldom quantified. Although the figures are not necessarily comparable across programmes, this report provides a few examples of programmes that have quantified the jobs created, ranging from tens of thousands in a smart-metering programme, to hundreds of thousands in a building efficiency programme. Given the political importance of employment creation, it is surprising that more programmes do not monitor it.

On the basis of the evidence gathered through the analysis presented in the report, three key messages for governments emerge:

- Autonomous energy efficiency improvements may be larger than previously anticipated. Yet, the scope for improvements is larger still, thus calling for additional efforts to increase the efficiency with which energy is transformed, distributed and used. Increased impetus to accelerate energy efficiency gains is most needed in countries where energy prices are unduly low, as they stand to lose competitive ground in the medium term.
- Most benefits associated with energy efficiency improvements are largely unaccounted for, which reduces the prospects for expanding current programmes and initiating new ones. Arguably, programmes should include appropriate performance monitoring provisions, which would help to make a strengthened case for heightened policy efforts in this area.
- To realise the full potential of energy efficiency, targeted information provision and capacity building activities are essential, as a number of well-known barriers can otherwise thwart progress toward increased efficiency in the transformation, distribution and use of energy. At present, these activities are often treated as ancillary aspects of programme design and, as a consequence, are usually underfunded.

Ultimately, the report highlights that, individually and collectively, countries have an interest in an improved understanding of how much energy can be saved, where, by when, and at what cost. This understanding can help develop more targeted and efficient measures to increase energy efficiency. In addition, such an improved understanding can help align those measures with national development goals and global climate change mitigation goals.

SUSTAINABLE ENERGY FOR ALL

The Sustainable Energy for All (SE4All) is one of the most overarching global initiatives that can help governments meet these challenges. This initiative was launched by the UN Secretary-General in 2011, with three interlinked objectives to be achieved by 2030: 1) ensure universal access to modern energy service; 2) double the global rate of improvement in energy efficiency; and 3) double the share of renewable energy in the global energy mix. This multi-stakeholder partnership brings together top-level leadership from all sectors of society – governments, business and civil society.

There are a number of activities to meet the energy efficiency objective, led by various organisations. Three examples are given here, for illustrative purposes:

- The **Global Tracking Framework** measures how the world is progressing toward SE4All, tracking country-level indicators for energy access, renewable energy and energy efficiency. A 2015 progress report shows that, while the rate of improvement in energy efficiency has grown during 2010-2012, this growth is insufficient to reach the sustainable energy goals by 2030.
- The **Global Energy Efficiency Accelerator Platform** currently comprises eight individual accelerators, covering: 1) lighting, 2) appliances and equipment, 3) district energy, 4) buildings efficiency, 5) transport and motor vehicle fuel efficiency, 6) industrial energy efficiency, 7) power sector and 8) finance. To achieve its goal of promoting energy efficiency, the Platform works with private sector partners and targeted regional, national or sub-national authorities.
- The **Readiness for Investment in Sustainable Energy (RISE)** initiative has developed a suite of indicators to assess the legal and regulatory environment for investment in sustainable energy. The indicators give an overview of the national enabling environment to attract investment into sustainable energy. A global rollout of 110 countries representing 91 percent of the global energy consumption will be available in 2016.

INTRODUCTION

The ‘emissions gap’ report series by the United Nations Environment Programme has provided ample insights into both the size of the so-called emissions gap and the range of options available to bridge it. In the 2014 issue the focus was on the extent to which improvements in energy efficiency could contribute to meeting global climate change mitigation goals (UNEP, 2014). In addition, the report outlined the many other benefits associated with energy efficiency improvements, from enhanced energy security, to reduced local air pollution, to improved industrial productivity, among others.[1]

Yet, progress in energy efficiency action has been slower than the potential gains may suggest. The different barriers that hinder the adoption of measures to improve energy efficiency are one main reason for this.[2] Against this background, governments around the world have introduced policies and programmes to overcome these barriers, with varying levels of success.

This report used two approaches to estimate the potential impacts and multiple benefits of improving energy efficiency. The first approach applied two energy-economy models to estimate the energy savings and associated greenhouse gas emission reductions that could be achieved by introducing a price on emissions of greenhouse gases. The analysis considered three scenarios that represented different carbon price levels of USD 40, USD 70 and USD 100 per tonne of carbon dioxide equivalent (CO_2e). These scenarios were compared against a ‘reference scenario’, projecting existing energy efficiency policies. Global and G20 country estimates were obtained and broken down by major economic sector. On the basis of these estimates, a third model was used to analyse the national-level macro-economic impacts of each scenario. The impacts of supply- and demand-side energy efficiency improvements were analysed for major economic sectors for most G20 countries and for the entire world.

Figure I.Overview of case studies, by thematic area

The second approach examined the multiple benefits of energy efficiency through a survey of twenty-five programmes across eight thematic areas (Figure 1). The survey provided qualitative insights into the economic, social and environmental benefits that are attributable to increased energy efficiency, which the macro-economic model cannot capture.[3]

This report is based on analyses solicited from four separate organisations:

- Enerdata provided estimates of energy use across several scenarios, using the POLES model;
- The Energy Research Centre of the Netherlands (ECN) provided the same type of outputs, using the TIAM model;
- Cambridge Econometrics provided estimates of the macro-economic impacts associated with the projections from the POLES and TIAM models; and
- DNV-GL researched and compiled 25 case studies describing the multiple benefits of energy efficiency programmes, including macro-economic impacts, but also focusing on other aspects such as human health and energy access.

These reports, as well as non-technical summaries of each of them, are available at http://www.unepdtu.org/.

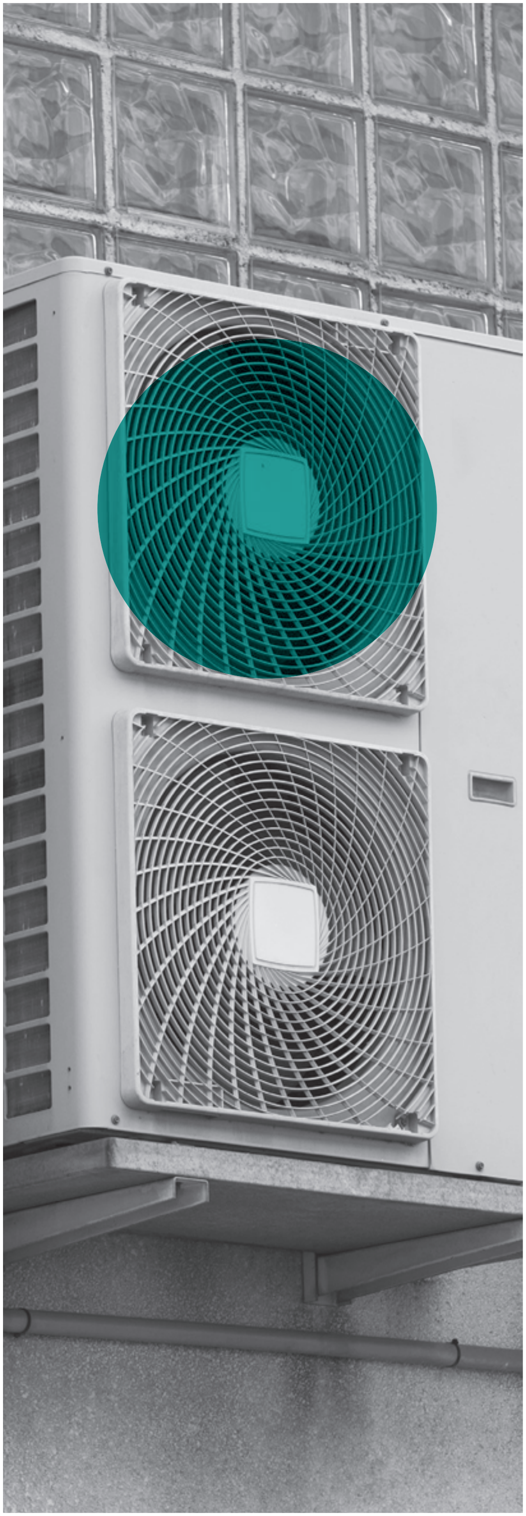
INTERNATIONAL NEGOTIATIONS

This report is being released at a critical time for international climate-change negotiations, as parties to the United Nations Framework Convention on Climate Change submit their so-called intended nationally determined contributions. These 'contributions' will shape the level of ambition of the new climate change agreement that is expected to be achieved in late 2015. As parties update and renew their 'contributions' to the agreement, they will have to rely on all available mitigation options and energy efficiency has the potential to be one among such options.

SUSTAINABLE ENERGY FOR ALL

The report supports the United Nations Secretary General's Sustainable Energy for All (SE4All), an initiative led by the United Nations Secretary-General and the President of the World Bank, where doubling the global rate of improvement in energy efficiency by 2030 is one of its three objectives. To meet this ambitious energy efficiency goal a range of economy-wide activities are required, including increased adoption of the types of programmes highlighted in this report. This report complements SE4All's Global Energy Efficiency Accelerator Platform, which was established to help reach this objective by driving action on, and commitments to, increase energy efficiency across all sectors of the economy.

In addition to this introduction, the report comprises three other chapters and five annexes. Chapter 2 summarises the projections from the modelling work. Chapter 3 summarises the results from the survey of national energy efficiency programmes. Chapter 4 provides some concluding remarks. Annex 1 outlines the approach, with sub-sections on: (i) projections of energy savings, emission reductions and macro-economic impacts, ii) results of the survey of national energy efficiency programmes, and iii) the main limitations of the methodology used. Annex 2 introduces the energy-economy models used, which were run with harmonised key assumptions and input data.[4] Annex 3 compares the results of this work with those from recent analyses. Annex 4 presents key model projections for most G20 countries[5], as well as for the world. Annex 5 gives a summary of the key findings from the survey of national programmes, structured around eight thematic areas.



PROJECTIONS

MODELLING THE IMPACTS OF A CARBON PRICE

This chapter presents key modelling projections of energy use, greenhouse gas emissions, and the macro-economic impacts of introducing a price on carbon. Annex 3 outlines the differences between this and related analyses, and highlights the reasons for any discrepancies. Annex 4 summarises the main modelling estimates obtained.

REDUCTIONS IN ENERGY SUPPLY AND DEMAND

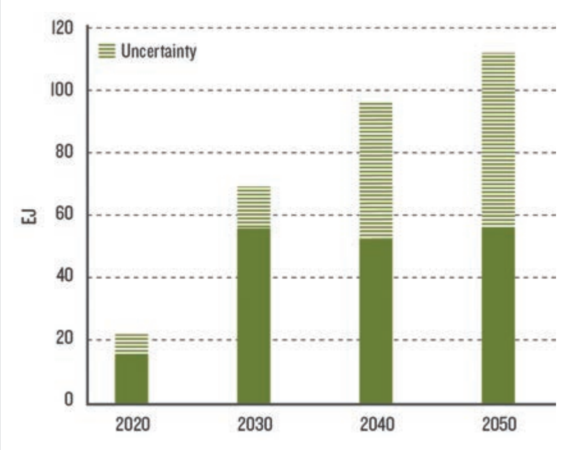
Total primary energy supply increases significantly in the reference scenario, with levels in 2050 almost doubling those in 2010.[6] This trend is slowed down somewhat under the different mitigation scenarios: in the period between 2010 and 2050, annual growth rates for total primary energy supply decrease from about 1.5 percent (in the reference scenario) to just above 1 percent (in the USD 100 scenario).

Nonetheless, we observe significant improvements in energy intensity in the reference scenario, where total primary energy demand per unit of gross domestic product decreases markedly throughout the period analysed (for example, a 40 percent decrease between 2010 and 2030).[7] The reduction is particularly important in the energy demand sectors, where fuel costs are higher than in the supply sector.

In the mitigation scenarios, China shows the largest reductions in total primary energy supply relative to the reference scenario, with a decrease of between 13 and 19 percent in 2030. Australia and the United States also show large relative reductions in total primary energy supply in the same year. In all these countries the ratio of energy demand to gross domestic product in 2010 is relatively high (China had the highest ratio of all countries modelled).

Figure 2. Primary energy demand reductions associated with improvements in energy efficiency

For a price of USD 70 per tonne of carbon, worldwide



Improvements in energy efficiency would save between 56 EJ and 69 EJ in 2030, and up to 110 EJ in 2050 (1 EJ corresponds to 23.9 million tonnes of oil equivalent)

Reductions in energy demand are most important in the electricity and industry sectors. This is true with regard to both the relative decrease in the mitigation scenarios compared to the reference scenario, and the absolute level of energy savings. In these two sectors, energy efficiency accounts for about 20 percent of the reductions in energy use, mainly through increased uptake of technologies that improve net power-plant efficiency and through the co-generation of electricity and heat.

MITIGATION OF GREENHOUSE GAS EMISSIONS

In the reference scenario, emissions of greenhouse gases increase by about 40 percent in 2030 compared to 2012. However, the rate of growth of greenhouse gas emissions is lower than the rate of growth of primary energy supply over the same period. This reflects autonomous improvements in energy efficiency, as well as autonomous increases in renewable energy-powered electricity generation.[8]

In the USD 70 scenario, and compared to the reference scenario, emissions of greenhouse gases are reduced by between 11 and 13 Gt CO_2e in 2030 (that is to say, emissions decrease to between 34 and 38 Gt CO_2e at the global level in 2030). For comparison, China's emissions in 2012 (excluding forestry and land-use management) were just below 11 Gt CO_2e. At the global level, energy efficiency improvements account for between 2.6 and

3.3 Gt CO_2e of the reductions in 2030, which is equivalent to between 23 and 26 percent of the overall reductions achieved in the USD 70 scenario.[9]

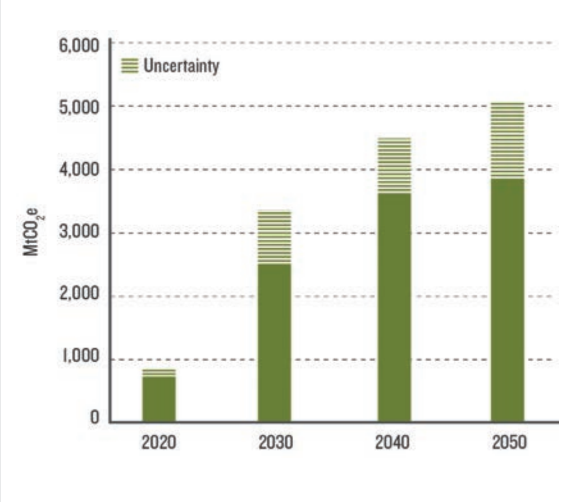
In the period between 2015 and 2030, cumulative greenhouse gas emission reductions attributable to improvements in energy efficiency are highest in China, the United States, India and Russia, which together account for about two-thirds of all cumulative reductions. In the USD 70 scenario, in the period between 2015 and 2030, China accounts for 39 to 45 percent of total cumulative greenhouse gas emission reductions attributable to energy efficiency, followed by the United States (9 to 10 percent), India (9 percent) and Russia (7 percent). In all mitigation scenarios G20 countries account for a majority share of total emission reductions (just below 90 percent) and of emission reductions due to improvements in energy efficiency.

Across all mitigation scenarios, greenhouse gas emission reductions attributable to energy efficiency are largest in the energy supply and industry sectors. Within the energy supply sector, savings are more important in upstream fuel production and conversion, and in combined electricity and heat production. Within the industry sector, non-metallic mineral production (mainly cement manufacturing) shows the most important savings.

Energy efficiency is responsible for most greenhouse gas emission reductions in the transport sector (mainly through more efficient fuel-use technologies for trucks and buses).[10] Conversely, energy efficiency plays a much smaller role in the energy supply and power generation sectors, where other mitigation

Figure 3. Greenhouse gas emission reductions associated with improvements in energy efficiency

For a price of USD 70 per tonne of carbon, worldwide



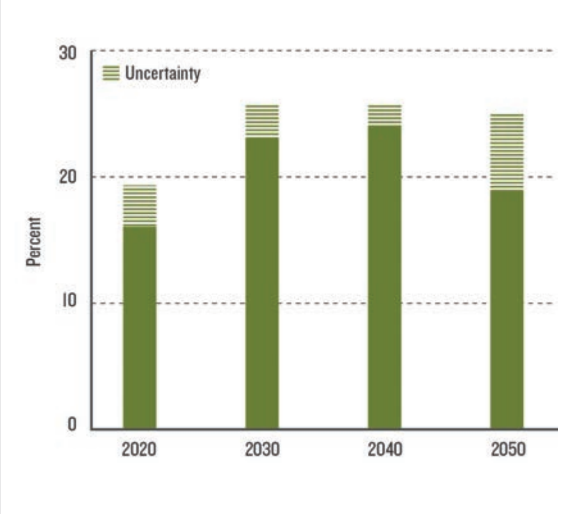
Improvements in energy efficiency would avoid between 2.6 and 3.3 Gt CO_2e in 2030, and up to 5 Gt CO_2e in 2050

G20 COUNTRIES

It is G20 countries that have the vast majority of the greenhouse gas emissions reduction potential associated with energy efficiency. Thus, from the point of view of climate change mitigation, it is critical that G20 countries achieve significant energy efficiency gains over the next decade. Nonetheless, from a development point of view, all countries stand to reap considerable benefits from improving the way they transform, distribute and use energy.

Figure 4. Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions, and relative to the reference scenario

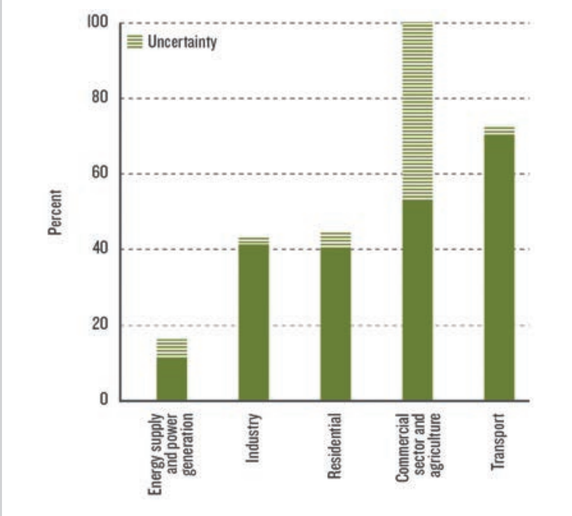
For a price of USD 70 per tonne of carbon, by year, worldwide



Energy efficiency accounts for between 16 and 26 percent of all economically-efficient greenhouse gas emission reductions

Figure 5. Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions, and relative to the reference scenario

In 2030, for a price of USD 70 per tonne of carbon, by sector, worldwide



Energy efficiency is the key greenhouse gas emissions mitigation option with regard to transport, but it plays a much smaller role in the energy supply and power generation sectors

MITIGATION POTENTIALS

An emissions reduction potential is a measure of the volume of greenhouse gases that could be abated by a future date, compared to a reference situation.[11] Technological potentials refer to the abatement volume that could be achieved by replacing, for example, all greenhouse gas emission-intensive equipment with state-of-the-art technologies, irrespective of cost. Economically-efficient potentials (or techno-economic potentials) refer to the share of the technological potential that would be economical to abate over a specified period of time, given a certain cost on emissions (additional, in comparison with the reference situation).[12] The analysis presented in this report refers to economically-efficient potentials.

options, notably changes in the fuel mix and carbon capture and storage, would account for most reductions in greenhouse gas emissions. Energy efficiency accounts for over 50 percent of all economically efficient greenhouse gas emission reductions in the commercial sector, and around 40 percent of the improvements in the industry and residential sectors.

ECONOMIC IMPACTS OF ENERGY EFFICIENCY

According to our analysis, improving the efficiency with which energy is transformed, distributed and used spurs economic growth: net economic impacts are positive in all cases considered, although the aggregate global-level impact is moderate.[13]

At the national level, two main factors will determine the impact on economic growth of measures aimed at improving energy efficiency:

- the more inefficient technologies are, and the lower energy prices are, the more likely it is that the impacts on economic growth of promoting energy efficiency will be negative in that country; and
- artificially low energy prices play a greater role than inefficient technologies, in that increasing prices is typically more challenging than replacing old technologies.

Globally, net changes in total employment are insignificant. However, national- and sector-level estimates vary markedly: for example, while jobs in mining, fossil-fuel production and utilities fall, employment typically grows in the construction and machinery sectors, which are the sectors that receive the most investment.

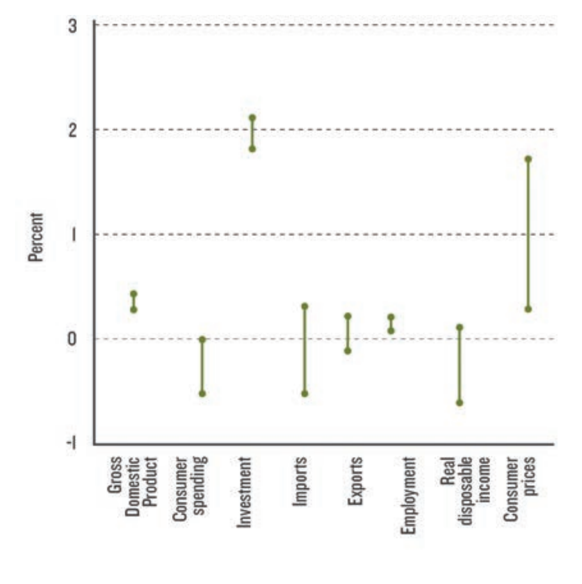
INVESTMENT

In our mitigation scenarios, economic growth is driven mainly by the investments required to accelerate energy efficiency improvement. These investments stimulate the economy despite the associated increase in electricity prices, industry costs or income taxes.

Depending on the prevailing domestic investment climate, some countries benefit from additional investments more than others, whereas other countries lose out due to reduced competitiveness and adverse price structures.

Figure 6. Macro-economic impacts associated with energy efficiency gains, relative to the reference scenario

In 2030, for a price of USD 70 per tonne of carbon, by type of impact, worldwide



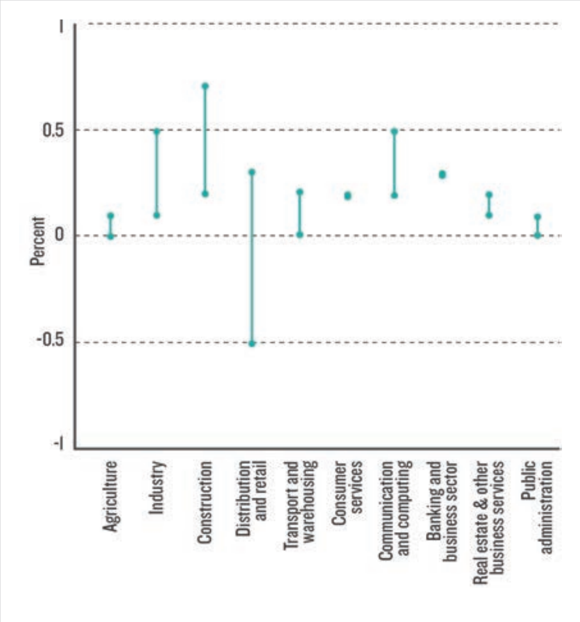
At an aggregate level, investments in energy efficiency do not constrain economic growth

Model outputs suggest the following additional macro-economic impacts:

- Energy-exporting regions see a reduction in energy exports, and thus energy-importing regions see an improvement in their trade balances.
- Both trade in, and domestic demand for, energy-efficient goods and services increases, as does the demand for raw materials in energy-efficient investment goods (for example, mechanical engineering and metal goods). As a result, regions exporting these goods are expected to increase their exports.
- Real disposable income decreases in regions where investments (to improve energy efficiency) are funded by government through rises in income taxes. Reductions in real disposable incomes are less significant in regions where investments are funded through higher prices.[14]

Figure 7. Sectoral output impacts associated with energy efficiency gains, relative to the reference scenario

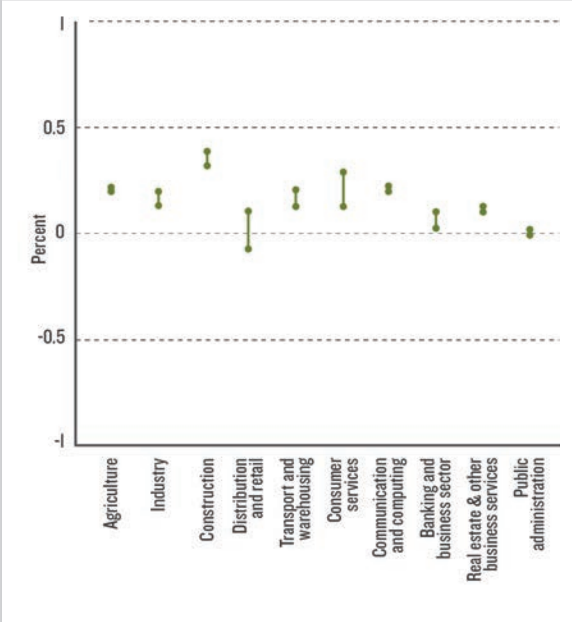
In 2030, for a price of USD 70 per tonne of carbon, by sector, worldwide



At the global level, investments in energy efficiency result in increased sectoral output in most economic sectors

Figure 8. Employment impacts associated with energy efficiency gains, relative to the reference scenario

In 2030, for a price of USD 70 per tonne of carbon, by sector, worldwide



At the global level, and in most economic sectors, investments in energy efficiency result in modest increases in sectoral employment

At the global level, both investment and consumer expenditure levels increase with the level of the price stimulus.[15] Increasing the price stimulus has a more marked impact on energy use and greenhouse gas emissions than it does on sectoral output and employment: while moving from the USD 40 to the USD 100 scenario results in relatively large additional reductions in energy use and greenhouse gas emissions, it only brings about marginal additional increases in sectoral output and employment.[16]

At the global level, growth in both sectoral output and employment is highest in the construction sector, which expands in most countries. It is lowest in the distribution and retail sector, which could contract in some regions. Changes against the reference scenario for a range of macro-economic indicators are most positive for China and most negative for Russia. Current levels of energy prices, trade in energy carriers and current levels of penetration of cleaner energy technologies account for most of the difference.

SURVEY

THE MULTIPLE BENEFITS OF ENERGY EFFICIENCY PROGRAMMES

A survey of policy programmes that have improved energy efficiency shed light on the nature and scope of the benefits associated with energy efficiency gains. Not least, the survey highlighted the extent to which our knowledge concerning these benefits is limited.

SURVEY OF NATIONAL PROGRAMMES

Governments across the world implement policies and programmes that affect the way energy is transformed, distributed and used. We surveyed twenty-five programmes, chosen on the basis of their perceived success in increasing energy efficiency (Annex 5).[17] The selection, which was contingent on data availability, covered eight broad policy areas in as wide a range of countries as possible (Figure 1).

Highlights from it include:

- **Energy savings and greenhouse gas emission reductions. Germany's building efficiency programme resulted in energy savings of 2,200 GWh in the period between 2008 and 2010, and avoided 0.8 Mt CO_2e in 2012. For comparison, these energy savings are equivalent to the electricity used annually by about 650,000 households in Germany.**
- **Economic growth, trade balances and energy prices. A demand-side management programme in Vietnam resulted in additional investment of USD 5.2 million between 2004 and 2010.**
- **Increased access to energy and reduced fuel poverty. Fuel poverty was prioritised in Peru's revised policy framework, which led to the replacement of 30,000 inefficient heaters by 2011.**

POLICY INSTRUMENTS USED IN PROGRAMMES THAT AFFECT ENERGY EFFICIENCY

An overwhelming majority of programmes surveyed relied on financial incentives of some kind, from direct subsidies for cleaner energy technologies, to revolving funds, to tax differentiation, to price rebates. Virtually all programmes contained some element of information dissemination, often as a complement to financial incentives. Only in a few instances was information dissemination the main tool used, and in those cases it was delivered through awareness-raising or training activities.

BARRIERS TO, AND ENABLERS FOR, PROGRAMME IMPLEMENTATION

The following paragraphs present summaries of barriers to, and enablers for, programme implementation. These summaries are structured around types of barriers and types of enablers.[18] Inevitably barriers and enablers overlap somewhat, in that the presence of a certain impediment constitutes a barrier, while the removal of that same impediment constitutes an enabler. A complementary summary by type of programme is provided in Annex 5.

BARRIERS TO PROGRAMME IMPLEMENTATION

Economic aspects. Subsidized energy prices prevented a higher programme uptake (across several types of programmes); caps on the financial incentives offered deterred potential participants, as did high upfront costs (across several types of programmes), while limited overall funding to broaden the programme prevented the inclusion of more technologies (in a standard and labelling programme).

Design considerations. Programme requirements (in a industry benchmarking programme) proved overly generic in light of the diversity of potential beneficiaries; perceived lack of privacy and concerns over data protection slowed down programme implementation (in a smart-metering programme); and the lack of penalties for non-compliance undermined programme credibility (in a financial mechanism).

Capacity levels. Limited technical expertise on the part of technical service providers and governmental programme managers slowed down programme implementation (across several types of programmes); lack of negotiating experience on the part of governmental programme managers compromised a programme in its early stages (in a voluntary agreement with industry); lack of testing and certification bodies became a key bottleneck (in a standard and labelling programme); and limited human capacity hindered market data collection (for a standard and labelling programme).

Awareness and information. Potential beneficiaries lacked awareness of the benefits of energy efficiency and lacked information about the programmes from which they could benefit (across several types of programmes); and lessons learnt from relevant related programmes were not available (in a building efficiency programme).

Administrative aspects. Inconsistencies with regard to the requirements of national and regional governments within the same country undermined programme uptake in certain regions of the country (in building efficiency and car-scrapping programmes); insufficient or ineffective coordination among actors slowed down programme implementation (across different type of programmes); and unduly burdensome administrative requirements, from enrolment paperwork to due-diligence procedures, deterred potential participants (across different types of programme).

ENABLERS FOR PROGRAMME IMPLEMENTATION

Economic aspects. Potential beneficiaries and, where relevant, finance institutions were offered incentives that compensated for costs and reduced risks (across different types of programme); ex-ante economic analyses made the case for the programme (in a smart-metering programme); and companies involved in the programme and operating multiple facilities benefited from economies of scale (in an industry benchmarking programme).

Design considerations. Clear enrolment procedures for potential beneficiaries and the one-stop-shop nature of the programme boosted enrolment (in car-scrapping and demand-side management programmes); engagement of independent experts strengthened the credibility of the programme (in building efficiency and demand-side management programmes); programme evaluation and revision, to adjust initial goals and procedures, and offer additional incentives, boosted enrolment (in a building efficiency programmes and a financial mechanism); negotiation through sectoral trade associations made it possible to reach numerous businesses with very different capacity levels (in a voluntary agreement with industry); and inclusion of peer pressure mechanisms increased compliance levels (in a voluntary agreement with industry).

Capacity levels. Government programme managers and, where relevant, technical service providers and financiers were trained to ensure effective programme delivery (across several types of programmes).

Awareness and information. Demonstration projects and lessons learnt from directly related programmes in other countries facilitated the development of, and enrolment in, the programme (in industry benchmarking, demand-side management and standard and labelling programmes); and targeted awareness-raising campaigns boosted enrolment in the programme (in a financial mechanism).

Administrative aspects. Binding regulatory requirements underpinned programme objectives (across several types of programmes); and strengthened enforcement procedures boosted programme enrolment (in a car-scrapping programme).

ENERGY SAVINGS AND GREENHOUSE GAS EMISSION REDUCTIONS

Detailed data on energy savings and avoided greenhouse gas emissions are scarce: projections exist but they are typically prepared at the design phase of the programme, while programme monitoring and ex-post assessments appear to be rare. By way of example, programmes for which ex-post assessments exist quote figures below 500 GWh annually for energy use and below 1 Mt CO_2e annually for greenhouse gases. Figures across programmes are not comparable because definitions differ and, most important of all, programme sizes and enrolment levels vary greatly.

REDUCTIONS IN LOCAL AIR POLLUTION

Among the programmes surveyed, only car-scrapping programmes consider their impact on local air pollution. Yet, beyond acknowledging the potential positive impacts, no further initiatives were implemented, such as setting up an air quality monitoring mechanism. The reason for this may be that these programmes were mainly aimed at spurring consumption during periods of slow economic growth: energy efficiency and environmental quality generally were secondary objectives. One projection was identified (from an Egyptian programme) which is arguably conservative: the programme is expected to reduce emissions of air pollutants by 1 percent annually in the period 2010-2019, compared to a reference situation.

ECONOMIC GROWTH, TRADE BALANCES AND ENERGY PRICES

Macro-economic impacts are somewhat narrowly measured in terms of, mainly, the monetary savings associated with reduced energy use and, to a lesser extent, in terms of growth in gross domestic product or value added. Two programmes use net benefits to society as a metric, while a third programme use additional investment. Broader benefits such as improved trade balances or impacts on energy prices are not monitored, possibly because estimating these impacts requires analysis that goes well beyond the remits of programme managers. Also, the programmes themselves may not be visible enough to feature in macro-economic analyses conducted by other parts of government.

PUBLIC SECTOR EXPENDITURE AND STRUCTURAL CHANGES IN THE ECONOMY

Impacts on public budgets are generally acknowledged, though seldom quantified. Unquantified references concern positive impacts due to tax income and social security contributions, reduced electricity costs associated with savings in public lighting systems, and avoided energy management planning and regulation. Quantified references concern reduced fuel subsidy expenditure, increased public finance costs (to run the programme) and reduced electricity costs associated with savings in public lighting systems. No programme considers the effects associated with structural changes in the economy due to (public-sector) investment in energy efficiency.

CREATION OF JOBS

Job creation is often recognised as a positive impact of the programmes. However, most references are qualitative. Quantitative estimates range from tens of thousands (for example, in a smart-metering programme) to hundreds of thousands (for example, in a building efficiency programme). Some estimates distinguish between jobs ‘created’ and jobs ‘preserved’, and between ‘direct’ and ‘indirect’ employment creation. Given the political sensitivity of the topic, it is surprising that programmes do not monitor employment creation.

IMPROVEMENTS IN HUMAN HEALTH AND WELL-BEING

Benefits to human health and well-being (for example, resulting from improved building insulation) do not appear to be monitored at all. Only anecdotal evidence could be identified: a car-scrapping programme estimated reductions in injury levels associated with the renewal in the vehicle fleet that the programme supported; a financial schemes programme cited targeted support to low-income families; and a regulatory reform programme referred to newly introduced incentives for efficient cooking stoves. The long causal chain from programme implementation to the reduced incidence of certain diseases compounds to programme managers not having the remit and resources to monitor these kinds of parameters, and results in a shortage of information on these issues.

INCREASED ACCESS TO ENERGY AND REDUCED FUEL POVERTY

Estimates of increased access to energy and reduced fuel poverty are also scarce.[19] Only three of the twenty-five programmes surveyed refer to them (of these, two are active in industrialised areas, and one is active in rural areas). In industrialised areas the programmes report reduced electricity bills, whereas the programme active in rural areas cites the replacement of inefficient heaters with more efficient ones.

BENEFITS TO ENERGY PROVIDERS

Little information could be identified concerning the benefits to energy providers in the form, for example, of reduced operating costs or increase reliability.[20] Not surprisingly, demand-side management programmes are amongst the few that note benefits to utilities. Specifically, they cite increased efficiency, increased reliability of supply and financial savings. A financial mechanism reports enhanced network reliability (through reduced load) as an ancillary programme benefit. None of these benefits are quantified.[21]

KEY OUTCOMES OF A SURVEY OF NATIONAL PROGRAMMES EFFECTING ENERGY EFFICIENCY

PROGRAMME TYPE	SCOPE	INSTRUMENT USED
BUILDING EFFICIENCY	Reducing energy use in existing buildings and supporting the construction of new buildings that meet certain minimum energy efficiency standards	Financial incentives in the form of soft loans (Germany) or grants (Germany, Sweden and United States), and information dissemination and training activities to complement the financial schemes (Germany, Sweden and United States)
CAR SCRAPPING	Renewing motor vehicle fleets through price stimuli aimed at bolstering consumption, retiring inefficient and unsafe vehicles, and reducing local air pollution	Financial incentives in the form of price rebates (China and Germany), direct subsidies (China and Egypt) and reduced vehicle-purchase tax rates (China and Germany)
DEMAND-SIDE MANAGEMENT	Smart metering (Austria and Vietnam) and financial incentives for upgrading technologies ranging from shower heads to industrial heat pumps (South Africa)	Financial mechanisms, including tariffs (Austria), subsidies (South Africa) and grants (Vietnam)
FINANCIAL MECHANISMS	Financial schemes aimed at facilitating the uptake of more energy-efficient technologies by reducing (perceived and actual) financial risks, making the economic case for those technologies, and disseminating both technical and financial information	Energy efficiency funds targeting industrial energy users (Thailand and Turkey), and rebates or loans for residential property owners (United States)
INDUSTRY BENCHMARKING	Reducing energy use in industrial facilities through benchmarking programmes to guide continuous improvements	Trading of energy efficiency certificates (India), energy audits combined with various information-sharing initiatives (Malaysia), financial and technical support delivered through local utilities (United States), and tax rebates for energy-intensive industries in exchange for energy-efficiency improvements (Sweden)
INSTITUTIONAL FRAMEWORKS	Establishing national governance structures and policy frameworks for energy efficiency, and mobilising funding for energy efficiency improvements	Financial schemes funded through both domestic and foreign budgets (Mexico and Peru), and action plans and long-term strategies with specific goals (Spain)
STANDARDS AND LABELS	Providing information on energy efficiency and typical annual energy consumption levels, and establishing mandatory minimum energy efficiency requirements for household appliances as well as industrial equipment and motor vehicles	Mandatory product labelling and mandatory minimum energy performance standards (Australia, Fiji and Vietnam)
VOLUNTARY AGREEMENTS	Improving the efficiency with which manufacturing plants use energy through voluntary programmes agreed between government agencies and sectoral associations	Targeted information materials and co-funding for energy efficiency projects (Canada), and standardized sectoral agreements laying out voluntary targets and the means envisaged to achieve them (Chile and Japan)

KEY BARRIERS	KEY ENABLERS
• Limited information dissemination • Governance inconsistencies • Limited financing levels	• Legal requirements • Incentives for financiers • Credibility through independent expertise • Opportunities to increase competitiveness • Evaluation and revision
• Limited awareness-raising • Low financial incentives • Cumbersome administrative requirements • Governance inconsistencies	• Appropriate financing levels • Clear and simple application procedures • Tightened-up enforcement procedures
• Limited stakeholder buy-in • Inadequate expertise among programme managers • Low electricity prices • Privacy concerns • Sub-optimal due-diligence measures	• Effective training programme • Customer-oriented programme managements • Thorough ex-ante analyses • Effective experience sharing
• Cumbersome administrative procedures • High upfront costs • High cost of monitoring equipment • Financing cap for capital-intensive projects • Lack of non-compliance penalty	• Independent monitoring and reporting • Effective training programme • Effective communications and branding • Ancillary financial measures • Reduced credit and performance risk through energy-service companies
• Difficult target setting across multiple, heterogeneous plants • Subsidized energy prices • Sub-optimal programme design (limited awareness, poor coordination, lack of monitoring and evaluation capacity) • High upfront costs	• Demonstration projects • Economies of scale • Fiscal incentives • Effective programme design (numerous trainings and effective coordination)
• Unduly narrow scope (focus on supply-side, ignoring demand-side) • Sub-optimal energy-price structures • Limited skills and capacity • Poor coordination • Overly rigid programme structure	• Effective awareness-raising campaigns • Appropriate financing levels • Streamlined governance structures • Legal requirements
• Unclear label content • Limited awareness • Insufficient capacities • Inadequate market data • Limited financial levels	• Relevant experiences from other countries • Removal of technical barriers through a purpose-designed project • Careful label design
• Limited awareness • Mutual mistrust (between government agencies and businesses) • Limited scope for improvements	• Appropriate financing levels • Effective mediation by trade associations • Legal requirements • Regulatory inducements

For a given type of programme, several national programmes were surveyed.

An issue that may have constituted a barrier in one programme (for example, limited financial incentives) may have constituted an enabler in another programme.

Thus, for the same programme type, an issue may be listed in both the barriers and enablers columns. More detail on the barriers and enablers specific to each programme are provided in Annex 5.

CONCLUSIONS

The reference scenario depicts a world in which competitiveness considerations spur savings in energy use. Putting a price on carbon, as represented by the three mitigation scenarios, brings about much higher levels of energy savings and associated reductions in greenhouse gas emissions. In addition, the investment in cleaner energy equipment promoted by putting a price on carbon raises global output and employment in many sectors of the economy.

These findings are consistent with the outcomes of a survey of twenty-five programmes affecting energy efficiency. Survey results highlight that, with appropriate inducements, and provided that the programmes succeed in removing barriers to implementation, programmes to promote energy efficiency can unlock energy efficiency gains well beyond the autonomous improvements portrayed in the reference scenario. The survey also suggests that the design of the programme is not only critical for its success: it is also an extremely challenging task, irrespective of its scope and the funding allocated to it. A successful programme design requires thorough ex-ante assessments, effective coordination among government agencies, an appropriate mix of incentives, practicable monitoring and reporting procedures, coupled with credible enforcement structures, and ex-post evaluation and revision mechanisms.[22]

Both model projections and evidence from actual programmes confirm that performance can be boosted:

- our mitigation scenarios consistently suggest that a higher price on carbon could deliver greater energy savings and more substantial macro-economic benefits; and

- the most ambitious programmes we surveyed appear to transform a sector or a technology market to an extent that more modest programmes cannot achieve, while at the same time bringing about comparatively higher economic, social and environmental benefits.

Therefore, if the funding to set up an ambitious programme is available, governments may want to consider prioritising such programme.[23] Benefit-cost ratios can be high, and the multiple benefits that the programmes can bring about – from reduced governmental expenditure, to increased local air quality levels, to reduced energy use, among others – are both necessary and popular public policy outcomes.

Three key messages for governments emerge from our findings:

- Autonomous energy efficiency improvements may be larger than previously anticipated. Yet, the scope for improvements is larger still, thus calling for additional efforts to increase the efficiency with which energy is transformed, distributed and used. Increased impetus to accelerate energy efficiency gains is most needed in countries where energy prices are unduly low, as they stand to lose competitive ground in the medium term.
- Most benefits associated with energy efficiency improvements are largely unaccounted for, which reduces the prospects for expanding current programmes and initiating new ones. Arguably, programmes should include appropriate performance monitoring provisions, which would help to make a strengthened case for heightened policy efforts in this area.
- To realise the full potential of energy efficiency, targeted information provision and capacity building activities are essential, as a number of well-known barriers can otherwise thwart progress toward increased efficiency in the transformation, distribution and use of energy. At present, these activities are often treated as ancillary aspects of programme design and, as a consequence, are usually underfunded.

ENDNOTES

1 Earlier analyses have documented the multiple benefits of energy efficiency improvements in much greater depth. Two examples include: the *Global Energy Assessment* (GEA, 2012), and the International Energy Agency's *Capturing the multiple benefits of energy efficiency* (IEA, 2014a).

2 Key barriers include imperfect information, split incentives and externalities. 'Imperfect information' refers to energy consumers not having adequate knowledge about the performance–cost ratio of an energy-using device compared to its alternatives. 'Split incentives' refers to technology or infrastructure owners not being motivated to invest in energy efficiency upgrades because the benefits associated with such upgrades do not accrue directly to them and offer a relatively low rate of return. 'Externalities' refers to energy users not being motivated to invest in energy efficiency because energy prices are unduly low (that is, prices do not correspond to the full costs to society). For additional information on barriers to energy efficiency, the reader is referred to UNEP, 2014 and IEA, 2014a.

3 The survey covers eight sectors. For each sector, three national policies are described (four, in one instance). The description includes a semi-quantitative assessment of benefits in the following areas: saving energy, reducing greenhouse gas emissions, improving local air pollution, increasing economic output and strengthening public budgets, increasing overall employment, improving human health and well-being, enhancing access to basic energy services and reducing fuel poverty, and helping energy providers by reducing operating costs and increasing network reliability.

4 These models cannot estimate energy efficiency directly. Nonetheless, they can be used to assess energy efficiency indirectly if a carbon price is imposed. The econometric model relies on the outputs of the two energy-economy models mentioned earlier. By running the econometric model with both sets of outputs, ranges can be obtained which give an estimate of the uncertainty in the projections.

5 Due to limited data availability, this report provides estimates for all but one of the G20 countries (Saudi Arabia). The G20 countries include Argentina, Australia, Brazil, Canada, China, the European Union, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom and the United States of America.

6 Total primary energy supply refers to the sum of energy production and imports, minus exports and storage changes.

7 Total primary energy demand refers to domestic demand for energy (for power generation, other energy sector uses and final consumption).

8 The various background reports (available online at http://www.unepdtu.org/) give additional information on the sectors in which these improvements would occur. (Note that a single MWh saved through energy efficiency gains will reduce greenhouse gas emissions more or less, depending on the technologies involved.)

9 This estimate diverges from other studies, such as the IEA's 'bridge scenario'. The IEA's 'bridge scenario' highlights that increasing energy efficiency can deliver 49 percent of energy savings by 2030, compared to a reference situation. Because the two studies have different underlying assumptions, comparing estimates is not possible.

10 While the energy supply and industry sectors show the highest greenhouse gas emission reductions in absolute terms, the transport sector shows the highest reductions in relative terms (that is, compared to emission levels in the reference scenario).

11 Emission reduction potentials may change over time because more efficient technologies become cheaper and because energy infrastructures reach the end of their operating life and need to be replaced. Therefore, for a given cost per unit of carbon abated, the size of an emission reduction potential will vary greatly not only across sectors and regions, but also depending on the period of time being considered.

12 Economic potentials that are aligned with the discount rates of private actors are often referred to as market potentials.

13 The various background reports (available online at http://www.unepdtu.org/) give additional information on the assumptions used in the economic analysis.

14 The econometric model used assumes that, where costs are passed on to consumers through increased prices instead of higher taxation levels, industry absorbs a part of the cost. For this reason the decrease in real disposable income is smaller when prices, not taxes, are used to transfer the costs of improving energy efficiency. Nonetheless, the economic burden to industry is partly offset by lower energy costs, due to the higher efficiencies achieved.

15 Investment increases at a faster pace, compared to consumer expenditure.

16 As per the definition of the Organisation for Economic Co-operation and Development, sectoral output refers to the output of an industry at a given level of aggregation that only reflects deliveries outside of the industry.

17 DNV-GL, a consulting, testing and certification company for the global energy sector, conducted the survey. The company has offices in over a hundred countries and, through these offices, has direct contact with national government agencies. The insights obtained through this large network were instrumental in informing the choice of programmes surveyed.

18 The text summarises the outcomes of the above-mentioned survey of national programmes. This survey sought to identify barriers and enablers that are specific to each programme surveyed. Because of this, more generic barriers and enablers, which are well described in the energy efficiency literature, were omitted. These include, for example, incentive structures, the fragmented nature of energy efficiency projects, the difficulties in agreeing legal and contractual arrangements on the basis of future reduced expenses, the setting of baselines, and a range of behavioural and non-price barriers. More broadly, the setting up of an appropriate regulatory framework has proved indispensable for the success of energy efficiency programmes. Not least, the creation of energy-service companies has played a particularly important role in certain regions, promoting not only energy savings, but also employment creation.

19 It is worth noting that determining the relative energy poverty of programme beneficiaries is notoriously difficult.

20 Most utilities' profits are a direct function of sales. When this is the case, energy efficiency improvements run counter to the utilities' financial interests, unless business models are changed to allow utilities to profit from energy efficiency gains. Note that, for power generators, energy efficiency does not systematically result in reduced costs (notably when it leads to unplanned shutdowns or to plant under-utilization).

21 Nonetheless, these benefits have been quantified in other instances. For example, wholesale (spot) electricity markets indirectly quantify the value of demand-side management programmes.

22 Programme design requires not only experience, but also resources. However, programme funders often neglect these aspects, as highlighted by the International Partnership for Energy Efficiency, an intergovernmental agency which advocates that "the human or financial support provided to energy efficiency programmes should not intervene or appear as a complementary or as a subsidy to the investment in energy efficiency as a whole, but instead as a catalyst, as the enabling environment" (IPEEC, 2014).

23 It is widely recognised that the chief barriers to increased energy efficiency are mainly non-price barriers: they refer to structural, institutional and behavioural issues. Yet, financing (in the form of a well-funded programme) is required to overcome those non-price barriers.

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ANNEX I

APPROACH

I. PROJECTIONS OF ENERGY SAVINGS, GREENHOUSE GAS EMISSION REDUCTIONS AND MACRO-ECONOMIC IMPACTS

The International Energy Agency (IEA, 2014b) defines energy efficiency as the act of "limiting or reducing energy consumption through the adoption of more efficient devices" (for example, the use of compact fluorescent light bulbs instead of incandescent light bulbs). According to this definition, "something is more energy efficient if it delivers more services for the same energy input or the same services for less energy input".

Energy-economy models can be used to estimate potential changes in the rate of adoption of more efficient devices. These estimates reflect the changes that could be expected in response to (hypothetical) variations in price that affect adoption rates and thus have the potential to increase efficiency. Estimates from energy-economy models correspond to the changes in adoption rates that it would be economically efficient to introduce. These may not coincide with the actual rates of adoption, because businesses and individuals may not behave in a manner that is economically efficient. On the basis of these estimates, models can project the associated reductions in primary energy demand or final energy consumption by a certain future year.

Reductions in primary energy demand are typically expressed as deviations from a reference situation – one in which price changes aimed at promoting increased efficiency will not be introduced. The magnitude of the deviation characterises the scope for improvements in energy efficiency. For this report four scenarios have been analysed: one reference scenario, and three scenarios representing hypothetical variations in price.

AUTONOMOUS ENERGY EFFICIENCY IMPROVEMENTS

The reference (or baseline) scenario includes so-called autonomous improvements in energy efficiency. These are improvements driven by causes other than price changes that are aimed at increasing the efficiency with which energy is transformed, distributed and used. For this reason, these improvements are reflected in the reference scenario.

Each price variation represents the combined impact of an undefined set of policy measures that could be implemented to promote energy efficiency, which together would amount to a price of USD 40, USD 70 or USD 100 (real 2005 prices) per tonne of carbon dioxide equivalent, depending on the mitigation scenario concerned. These price levels were chosen because they are consistent with those examined in the literature and because they are compatible with the parametrization of the models used in the analysis. The background reports that informed this report provide additional information on how the carbon price is implemented in each model. For a given variation in price, the impact it could have on primary energy demand is assessed for the years 2020, 2030, 2040 and 2050. Most of the results presented refer to 2030, because this is a key year with regard to international climate change negotiations, including the target year for the SE4All initiative.

The estimates of primary energy demand presented in this report have been calculated using two energy-economy models: TIAM-ECN and POLES. These models were chosen because they are well established, the respective modelling approaches are complementary, and because the models provide both global and national-level coverage. Prior to running the models, key assumptions and input data were harmonised by the modelling teams, to ensure that model outputs would be comparable. Nonetheless, model outputs are obviously not identical, because the modelling paradigms are different.

POLES is a partial-equilibrium simulation model, whereas TIAM-ECN is a linear optimisation model. Annex 2 provides more detail of each model.

Both POLES and TIAM-ECN divide energy-consuming activities into power generation and end-use sectors (namely, industry, transport, buildings and agriculture). Each activity is in turn broken down into a range of representative technologies. For a given carbon price, the models adopt several technologies simultaneously to a greater or lesser extent, depending on relative price changes at the sectoral level (POLES), or depending on individual technology costs among a large set of technology options with different fuel conversion efficiencies (TIAM-ECN). This contrasts with the approach taken in marginal abatement cost curves, in which paradigm a technology is adopted when it is economically efficient to do so. If this condition is met, the technology will be adopted across all sectors and countries. The next most expensive technology is only adopted (also fully) if and when the price stimulus is high enough. We believe that such discrete, lumped adoption of technologies is less realistic than the approach taken in this study.

To conduct the analysis presented in this report, the technologies referred to in the previous paragraph have been classified as either affecting or not affecting energy efficiency. For example, in the transport sector, the impact of changes in the share of biofuels is categorised as not affecting energy efficiency, whereas the impact of changes in the share of efficient vehicle engines is categorised as affecting energy efficiency.

MODELLING THE PRICE STIMULUS

The carbon tax is applied to all greenhouse gas emissions, whether they result from combustion processes, industrial sources, or any other energy sector-related source of emissions. Apart from the carbon tax, no further climate change mitigation policies or support schemes for low-carbon technologies are assumed for the future.

ADDED VALUE OF THE APPROACH

Most global forecasts for the energy sector reflect the combined impact on primary energy demand of changes in energy efficiency and changes in the fuel mix. As a result, using these forecasts, it is difficult to isolate the individual impact of measures aimed at improving energy efficiency. This is problematic because a better understanding of the specific impact of energy efficiency measures could help prioritise energy efficiency programmes (for example, across technologies or world regions). It could also contribute to raising awareness about the actual performance of energy efficiency programmes, which in turn could help promote energy efficiency improvements. The analysis presented in this report focuses exclusively on energy efficiency, thus contributing to bridging these gaps.

Outputs from a single model will typically be expressed as point-value estimates. When two models are run to produce distinct, but comparable estimates of likely future trends in any one parameter, these estimates can be expressed as a range. Ranges are more informative than point-value estimates because they quantify some of the uncertainty inherent in any projection. The analysis presented in this report is based on two models, with a view to providing ranges for the estimates of likely future trends in primary energy demand and related variables. While quantifying uncertainty does nothing to reduce it, it supports more informed decision-making. This is because, compared to point values, uncertainty ranges give decision-makers more information with regard to the likely outcomes of their decisions. Besides, analysing uncertainties can help improve the decision-making process itself, notably by bringing additional scrutiny into the factors at play, and by promoting consensus in definitions and objectives.

The estimates of primary energy demand obtained through POLES and TIAM-ECN are used as input to E3ME, a macro-economic model. E3ME uses these projections to give estimates of likely future trends in, for example, gross domestic product, consumer prices, employment or exports. Since E3ME relies on two sets of projections of primary energy demand, the estimates it produces are expressed as ranges, thus providing a rough quantification of the uncertainty around those estimates. Annex 2 gives additional information on the three models used.

II. SURVEY OF NATIONAL ENERGY EFFICIENCY POLICIES

A survey was conducted of twenty-five national programmes that have an impact on energy efficiency, covering eight diverse areas: building efficiency, car scrapping, demand-side management, financial mechanisms, industry benchmarking, institutional frameworks, standards and labels, and voluntary agreements (Figure 1). Three national programmes were surveyed for each area (four, in the area labelled 'industry benchmarking'). Information was sourced from existing evaluations (where available) and from direct contacts with key programme actors. Significant efforts went into ensuring that, across sectors and countries, respondents had a shared interpretation of the information being requested from them. Full case studies are included in a technical report, a summary of which is also available online. Both reports can be accessed online at http://www.unepdtu.org/. Annex 5 summarises the main conclusions of the survey, by thematic area.

III. LIMITATIONS OF THIS APPROACH

The study faced several constraints, the most important of which are summarised in the following paragraphs.

Likely future developments in model input parameters are obviously uncertain, and the assumptions made regarding these developments determine model outputs to a great extent: the more off-target assumptions turn out to be, the more off-target model outputs will be. Our assumptions are outlined in the corresponding technical reports (the reports are available online at http://www.unepdtu.org/). Key parameters include national-level gross domestic product growth rates, fuel prices, and so-called learning rates for cleaner technologies.

The POLES model is a so-called hybrid model. In this type of model, outputs concerning final energy demand are calculated on the basis of econometrically determined relations. Such relations might not be valid at very high price ranges for carbon dioxide. Similarly, investments in retrofitting existing power capacities or energy-consuming equipment are not modelled, which might affect the relative attractiveness of energy efficiency as an option for emissions reductions.

TIAM-ECN, like the TIAM family of models more generally, ranks among the most detailed models with regard to its technology breakdown. Nonetheless, increased technological detail would be needed to enrich the analysis of potential energy efficiency improvements. In particular, additional detail would be needed for the industry and building sectors.

E3ME is an econometric, non-optimization model. Possible concerns with regard to its econometric nature relate mainly to the validity of past regression coefficients for describing the future. Shortcomings with regard to its non-optimization nature relate to the lack of data on workforce skills: the model allows for the possibility of spare economic capacity, including labour force capacity, and allocates workers without taking account of their skills.

Lack of data constrained the survey of national policies: cases were only included in the final set if enough information could be obtained for all or most of the parameters being investigated. In only a few cases had independent evaluations been conducted, which could be used to contrast official performance reports. In all other cases, unverified official data was used. Isolating the contribution of energy efficiency to the benefits achieved by any one programme was challenging in all instances.

ANNEX 2

OVERVIEW OF THE MODELS USED

POLES

POLES is a world energy-economy, partial-equilibrium, simulation model of the energy sector, with complete modelling from upstream production through to final user demand. The model combines details of key components of the energy system with strong economic consistency, as all changes in these key components are influenced by relative price changes at the sectoral level. Moreover, the POLES model allows for dynamic technological change and takes due account of price-induced technology-diffusion mechanisms such as feed-in tariffs.

For this analysis the POLES model considers fifteen energy-demand sectors, corresponding to more than forty technologies. Unlike TIAM-ECN, the other energy-sector model used for the study, POLES does not include emissions from land-use change or emissions of nitrous oxide. To increase the comparability of the estimates from both models, estimates from the TIAM-ECN model exclude emissions from land-use change and nitrous oxide.

TIAM-ECN

TIAM-ECN is a linear economic optimization model, based on energy system cost-minimization with perfect foresight until 2100. It simulates the development of the global energy system over time, from resource extraction to consumption of final energy, to satisfy the demand for useful energy. Like any energy systems model, TIAM-ECN can analyse greenhouse gas reduction pathways over the entire energy supply chain, up to end-use energy demand. In this way, horizontal and vertical interdependencies and the substitution effects of the energy supply can be incorporated into the analysis. Besides this integrated approach, TIAM-ECN features the peculiarities of energy extraction, conversion and demand, like available fossil and renewable resources, potentials of storage of carbon dioxide and region-specific demand developments.

TIAM-ECN is operated with a comprehensive technology database that includes many possible fuel-transformation and energy-supply pathways, and encompasses technologies based on fossil, nuclear and renewable energy resources. Both currently applied technologies and future advanced technologies are available in the model's technology portfolio. With regard to climate change mitigation measures, the model covers reduction options for the three main greenhouse gases, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), from both energy- and non-energy-related emission sources. TIAM-ECN also covers emissions from land use, land-use change and forestry.

E3ME

E3ME is a computer-based model of the world's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe and beyond for purposes of policy assessment, forecasting and research. The global edition is a new version of E3ME, which expands the model's geographical coverage from 33 European countries to 53 global regions. It thus incorporates the global capabilities of the previous E3MG model.

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. In total there are 33 sets of econometrically estimated equations, including the components of gross domestic product (consumption, investment and international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

E3ME has been used previously to assess the economic and labour market impacts of energy efficiency in Europe for both the Energy Efficiency Directive and related European Union targets for 2030. In both cases, E3ME used the results from the PRIMES energy model to carry out the assessment and found that there could be a small benefit to Europe's economies from implementing an ambitious energy efficiency programme.

ANNEX 3

COMPARING OUR RESULTS WITH THE RESULTS OF OTHER STUDIES

Many global studies exist that explore how the various climate change mitigation options can be combined to meet certain emission reduction targets. Unless it is excluded by design, energy efficiency is always on the set of options considered. However, studies seldom present disaggregated findings (by country, sector and mitigation option).[1] As a result, relatively little information is available on the role of energy efficiency improvements disaggregated by country and sector. Appendix 4.C to the 2014 update of UNEP's 'emissions gap' report gives an overview of recent studies that do provide some level of disaggregation.[2]

Most of these studies give estimates of greenhouse gas emission reduction potentials within energy efficiency. A comparison of these estimates provides a synthetic view of the relative importance that each study gives to energy efficiency. Estimates range from between 7 Gt CO_2e and 14 Gt CO_2e at the global level, annually in 2030.[3] The discrepancy arises from (i) the base year being considered, (ii) the different assumptions made with regard to fuel costs, gross domestic product growth rates and technology costs, and (iii) the different modelling approaches used.

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1 Studies based on models that feature national detail may produce this level of disaggregation. However, because most studies present their findings at the supranational level, national- and sector-specific details are most often not published.

2 The appendix is available online at http://www.unep.org/publications/ebooks/emissionsgapreport2014/

3 These estimates are based on, respectively, 2011 and 2000 base years.

The results presented in this report are lower: between 2.6 Gt CO_2e and 3.3 Gt CO_2e at the global level, annually in 2030 (based on a 2015 base year), and using a price on carbon of USD 70 per tonne. The smaller size of the estimates is due to differences in definitions, assumptions and modelling approaches. Specifically, three main factors account for the discrepancy between our estimates and those produced in earlier analyses:

Differences in the reference scenario. The reference scenario used for this study is lower than that of some other studies. This is because, as mentioned earlier in this report, our reference scenario assumes a higher rate of so-called autonomous energy efficiency improvements, compared to that in other studies. Assumptions about the size of these improvements vary across models and are known to be an important determinant of the resulting model outputs. For example, in TIAM-ECN, emission reductions worth 3 Gt CO_2e was assumed to be economical in the absence of additional price stimuli and, therefore, they were included in the reference scenario.

Energy efficiency measures with negative costs. Other studies include energy efficiency measured at negative cost when the discounted investments are compared to the savings over the entire lifetime. Conversely, one of the models used in this study (POLES) considers energy efficiency increases only with price increases (or technological enhancement) and thus necessitates a price stimulus to produce energy efficiency enhancements over time.

Cost-effectiveness of energy efficiency measures in the long term versus measures induced by the carbon price. The scenarios in this study were obtained by inducing changes in the energy system with the addition of a carbon price. Both the measurement of cost-effectiveness and the investment decisions related to energy efficiency were made on the basis of the economic parameters associated with a given year (that is, with imperfect knowledge of the future). A different approach – for example, modelling with cross-temporal optimization – could yield different results in cost-effective pathways.

ANNEX 4

SUMMARY OF MODEL ESTIMATES

The following pages give a graphic overview of the model projections obtained through the work described in this report. Estimates are available for most G20 countries.

Where possible, estimates from two models are presented in the form of a vertical line extending from the estimate given by one model to the estimate given by the second model. In the cases where estimates from only one model could be obtained, they are presented as point values.

In the cases where estimates from two models could be obtained, most pairs of estimates are fairly consistent. Nonetheless, in a few instances there is a noticeable or even large discrepancy in the estimates.[1] Those pairs of estimates are included in this summary, stressing that likely developments in the relevant countries and sectors are particularly uncertain.

In the case of South Africa, the estimates that could have been produced using the macro-economic model described in Annex 2 were considered to be too uncertain and have not been included. No estimates could be produced for Saudi Arabia.

Greenhouse gas emissions data included in the vertical bar at the beginning of each G20 country summary have been obtained from the World Resources Institute (RI, CAIT 2.0. 2014. Climate Analysis Indicators Tool: WRI's Climate Data Explorer. Washington, DC: World Resources Institute. Available at: http://cait2.wri.org).

1 This is common in analyses involving several models, and is due to differences in model structures and in the subset of model assumptions that have not been harmonized to preserve the various modelling approaches.

LEGEND

TOTAL GREENHOUSE GAS EMISSIONS
($MtCO_2e$, in 2011, excluding land-use change and forestry)

TOTAL GREENHOUSE GAS EMISSIONS PER PERSON
(tCO_2e by inhabitant, in 2011, excluding land-use change and forestry)

TOTAL GREENHOUSE GAS EMISSIONS PER UNIT OF GROSS DOMESTIC PRODUCT
(tCO_2e by ten thousand international dollars PPP, in 2011, excluding land-use change and forestry)

ARGENTINA
IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

UP TO

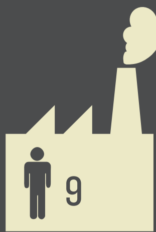
44 $MtCO_2e$

REDUCED THROUGH ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 0.1 AND 1.3 PERCENT GROWTH IN

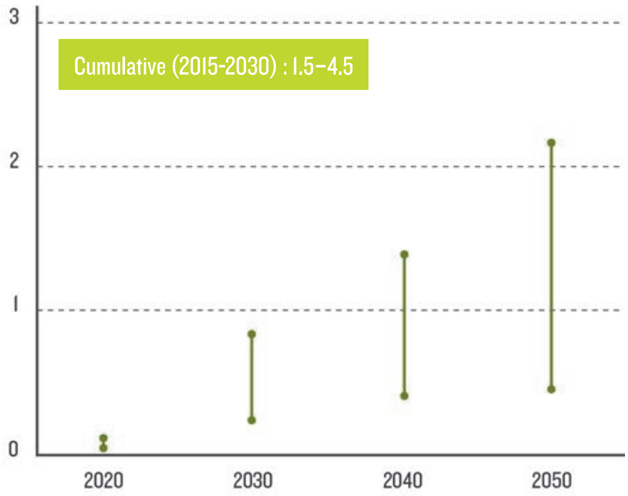
EMPLOYMENT

IN THE INDUSTRY SECTOR, COMPARED TO THE REFERENCE SCENARIO



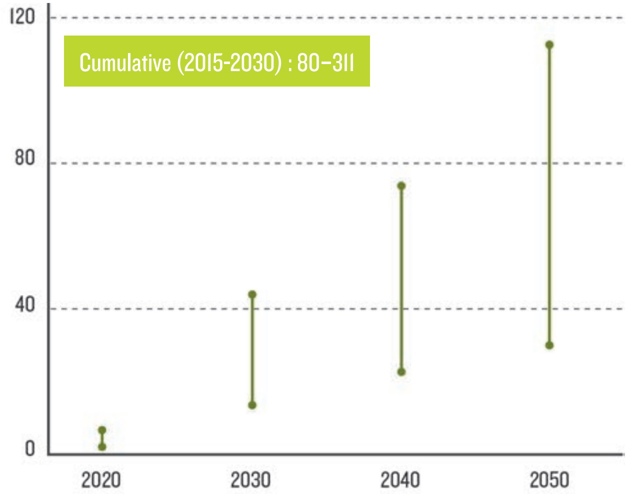
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



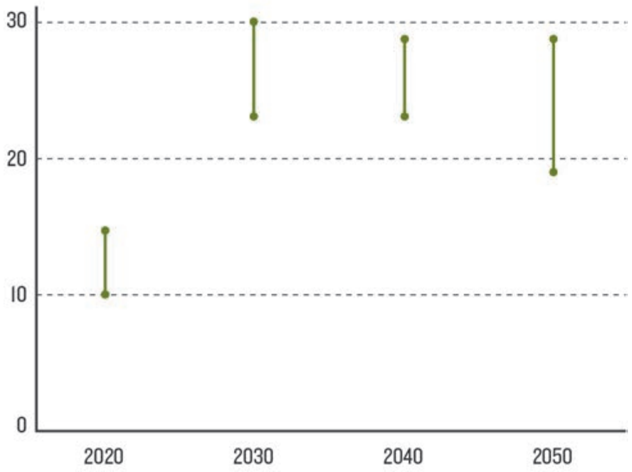
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



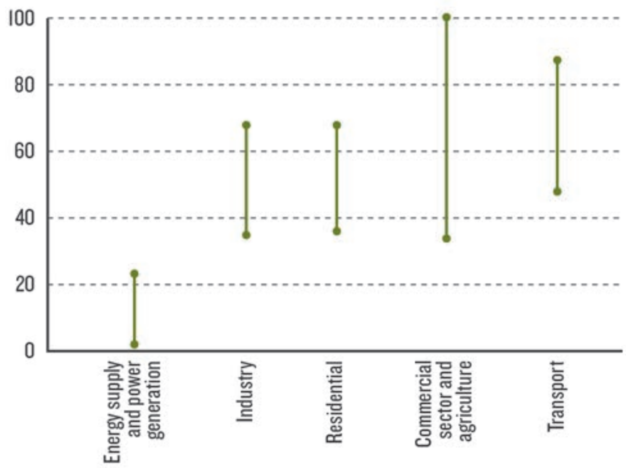
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



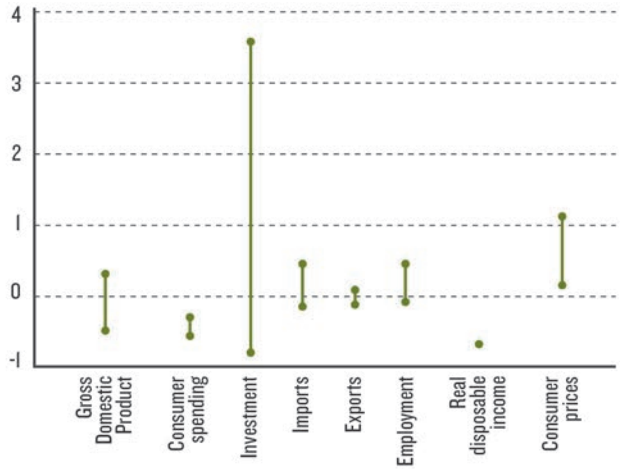
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



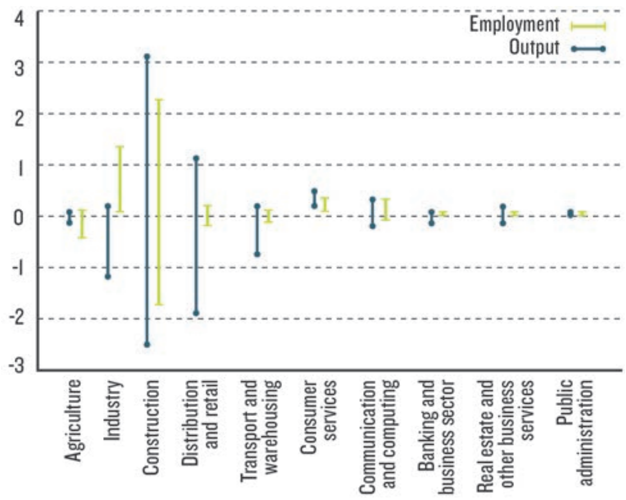
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



AUSTRALIA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

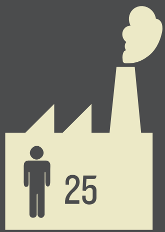
0.9 EJ

SAVED THROUGH ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 1.5 AND 3.4 PERCENT GROWTH IN

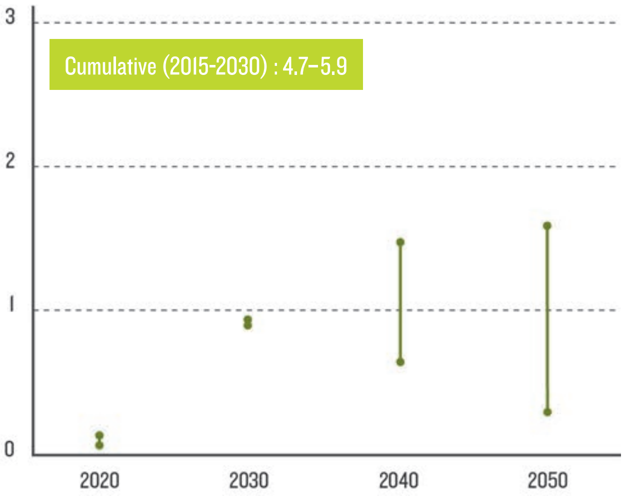
INVESTMENT

COMPARED TO THE REFERENCE SCENARIO



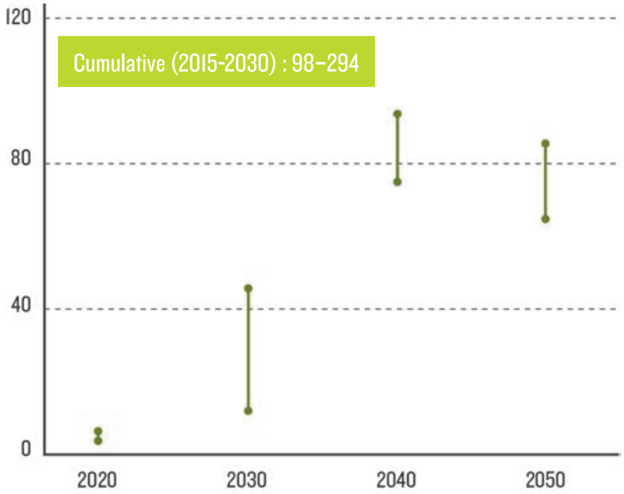
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



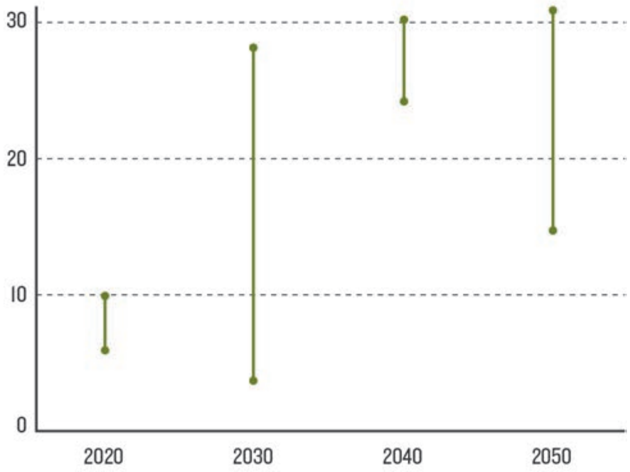
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



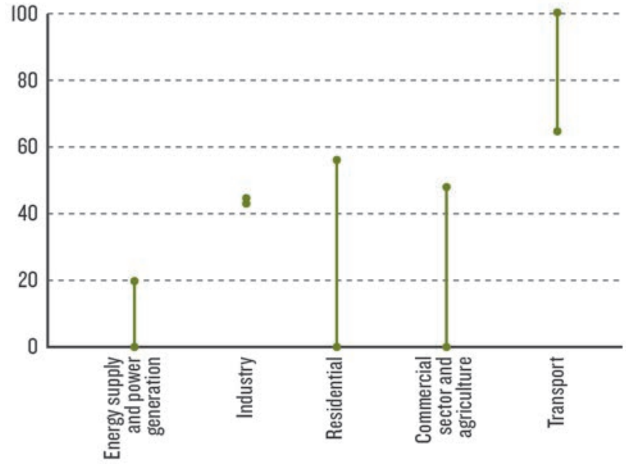
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



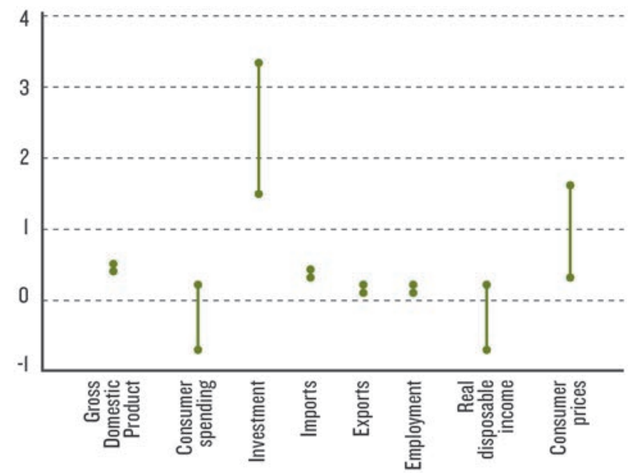
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



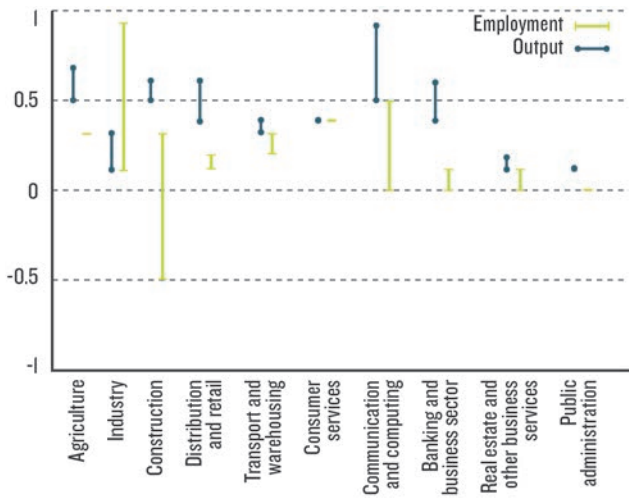
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



BRAZIL

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

UP TO

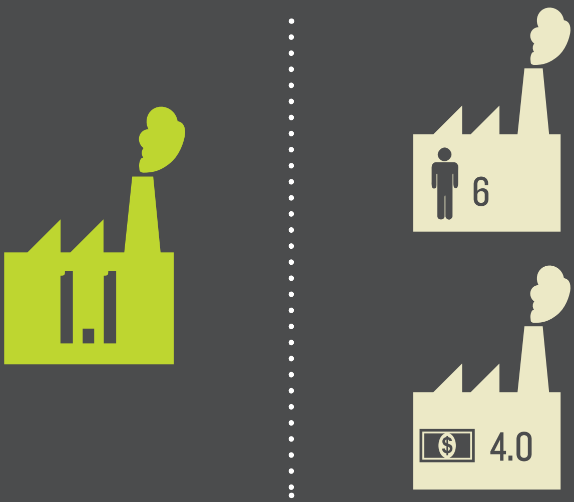
34.9 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 0.7 AND 1.2 PERCENT GROWTH IN

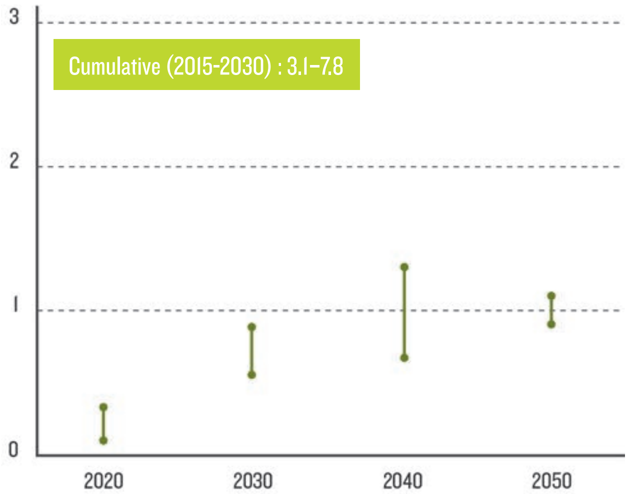
GROSS DOMESTIC PRODUCT

COMPARED TO THE REFERENCE SCENARIO



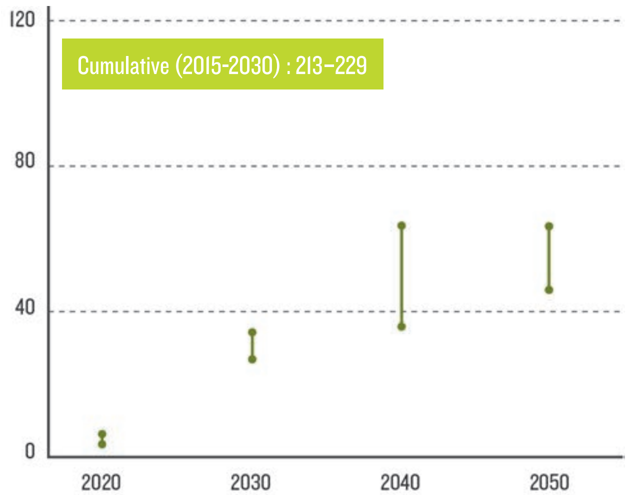
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



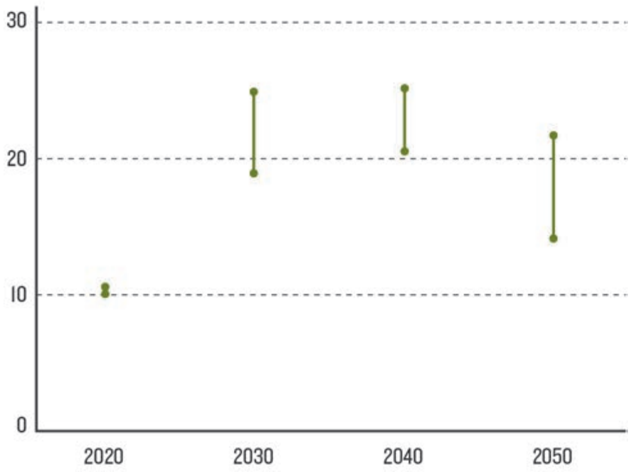
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



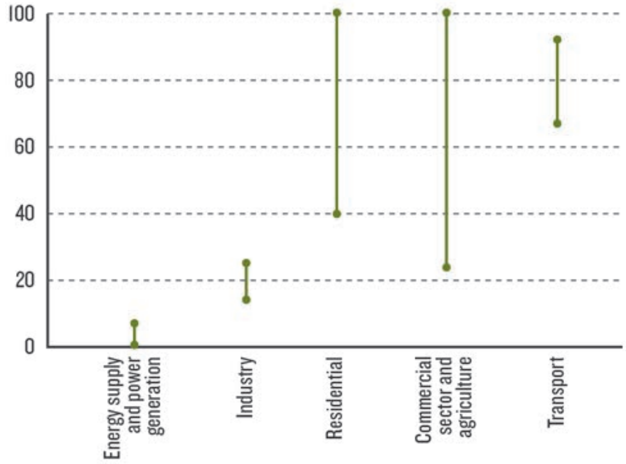
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



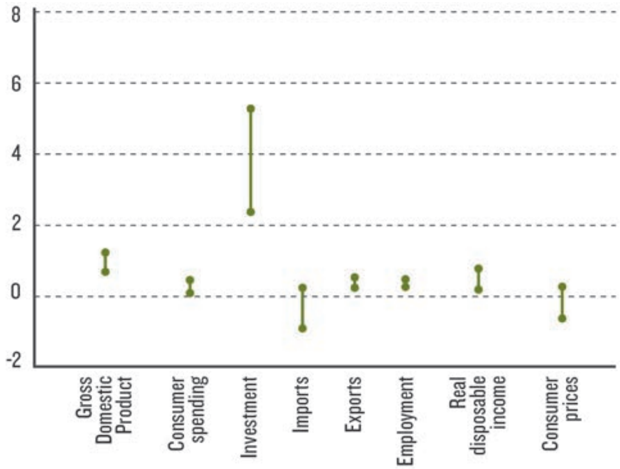
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



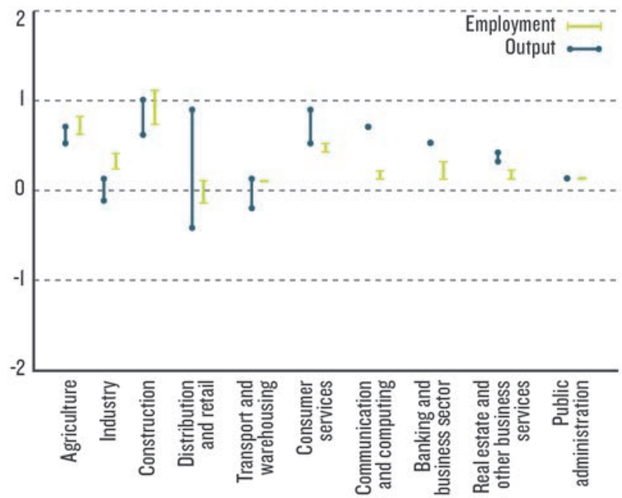
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



CANADA

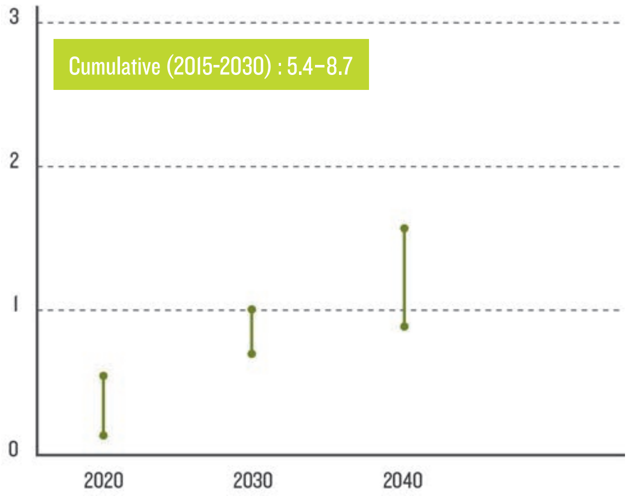
IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

UP TO
1 EJ
SAVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

UP TO 40 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE
INDUSTRY SECTOR
WOULD BE ACHIEVED THROUGH ENERGY EFFICIENCY IMPROVEMENTS

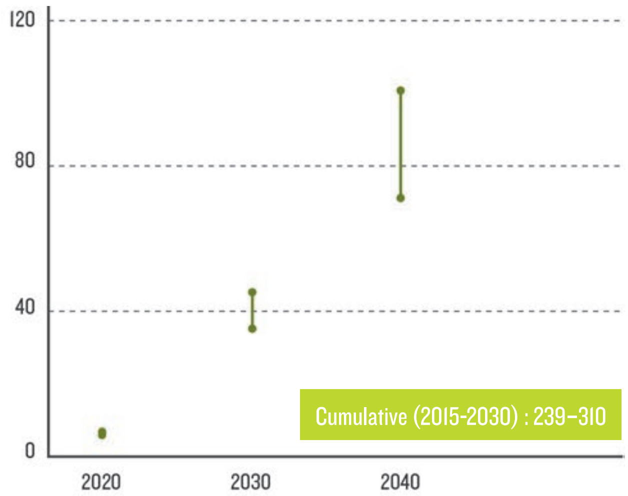
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



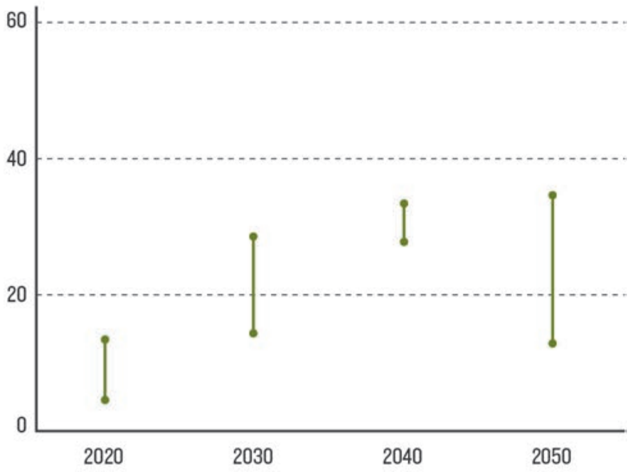
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



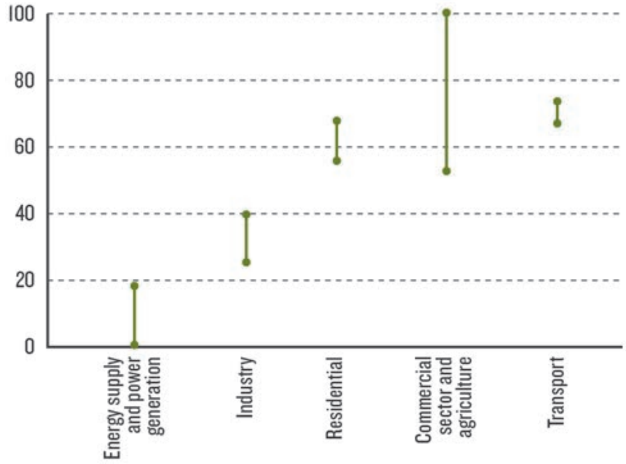
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



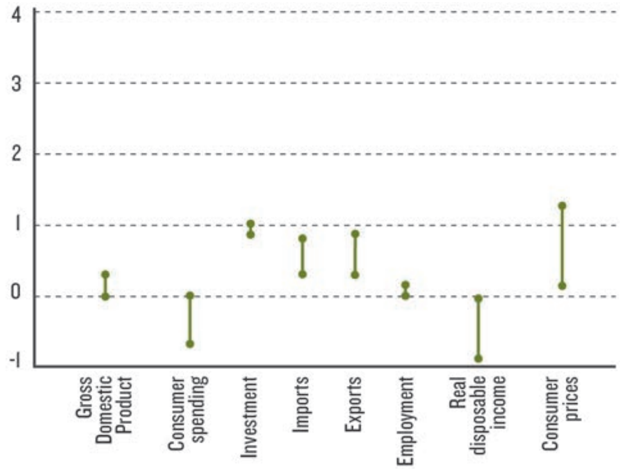
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



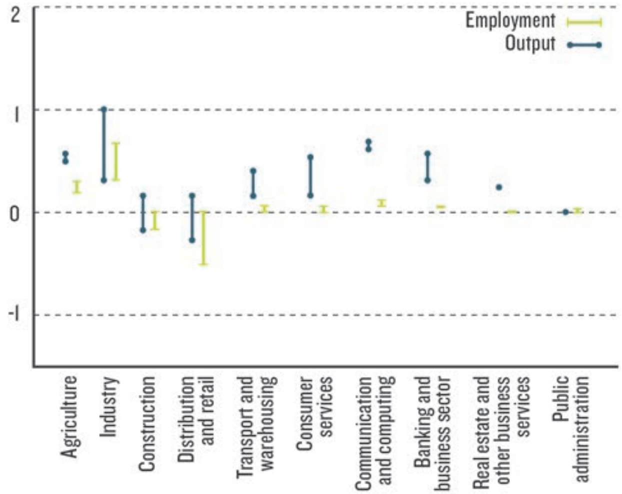
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector

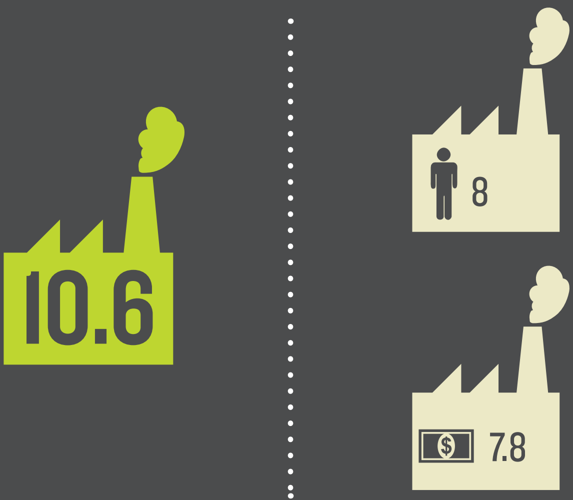


CHINA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

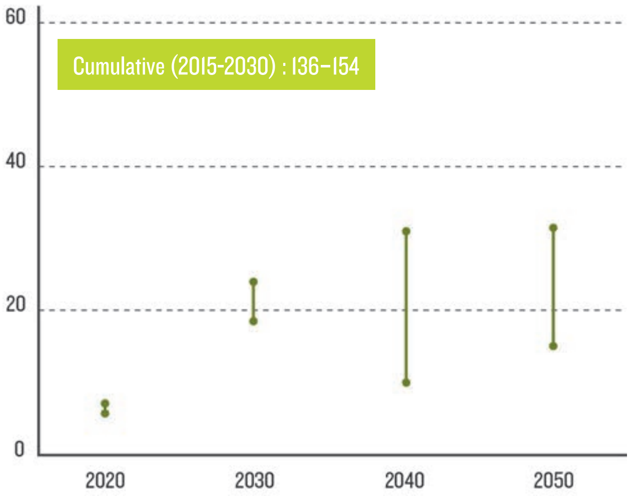
UP TO
24.3 EJ
SAVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 3.7 AND 4.3 PERCENT GROWTH IN
INVESTMENT
COMPARED TO THE REFERENCE SCENARIO



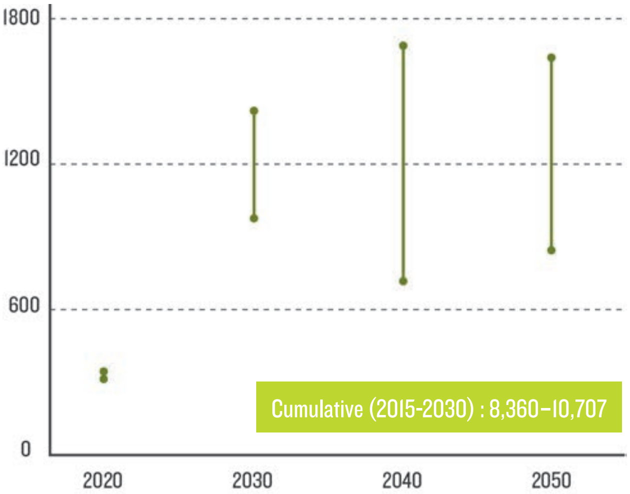
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



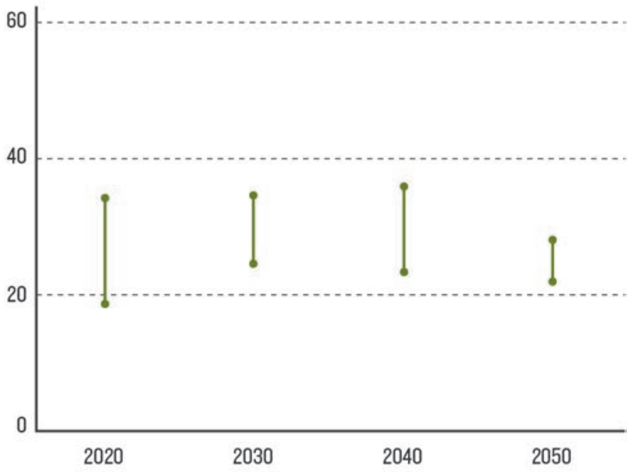
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



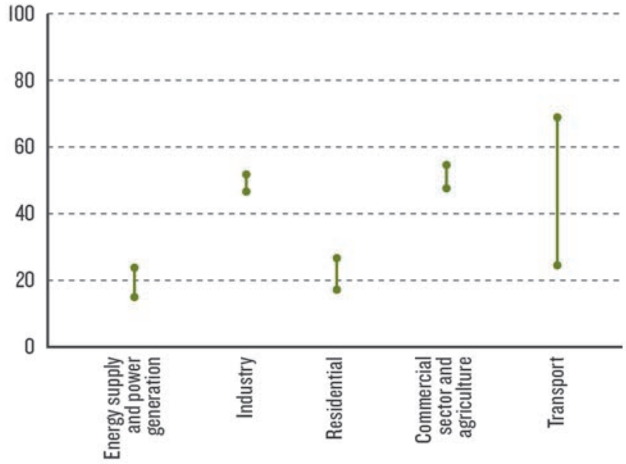
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



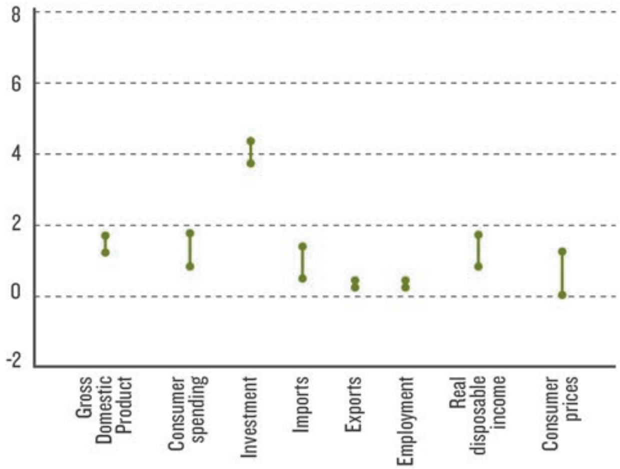
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



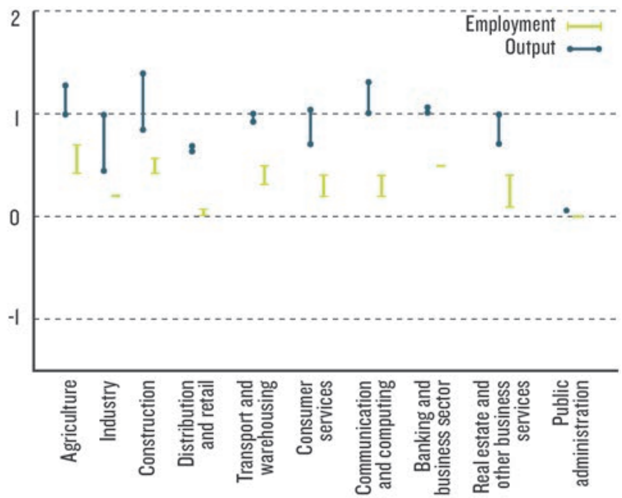
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



EUROPEAN UNION

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

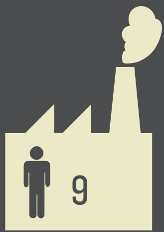
118 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 0.1 AND -0.5 PERCENT CHANGE IN

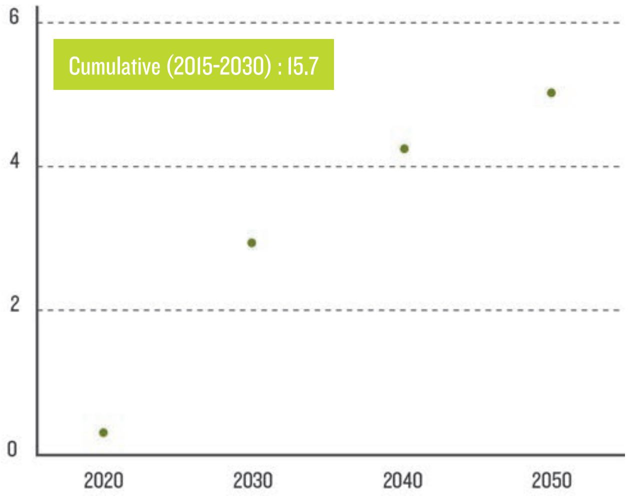
IMPORTS

COMPARED TO THE REFERENCE SCENARIO



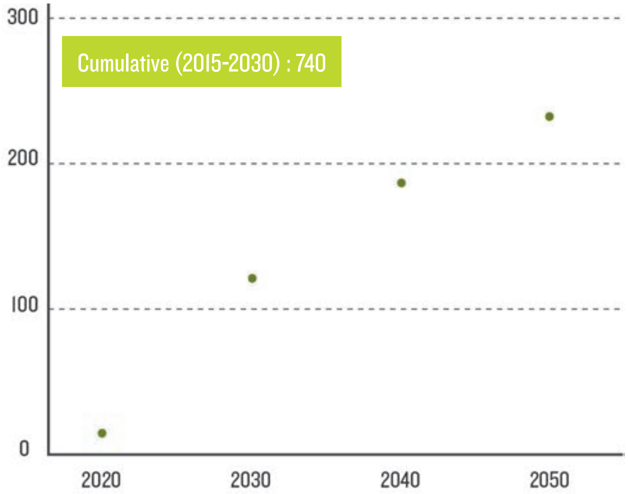
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



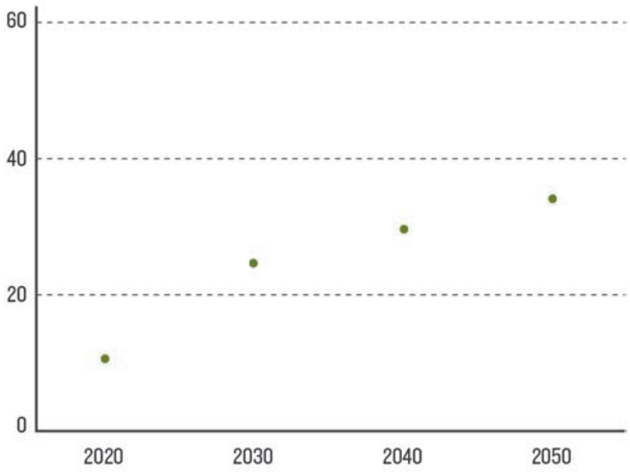
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



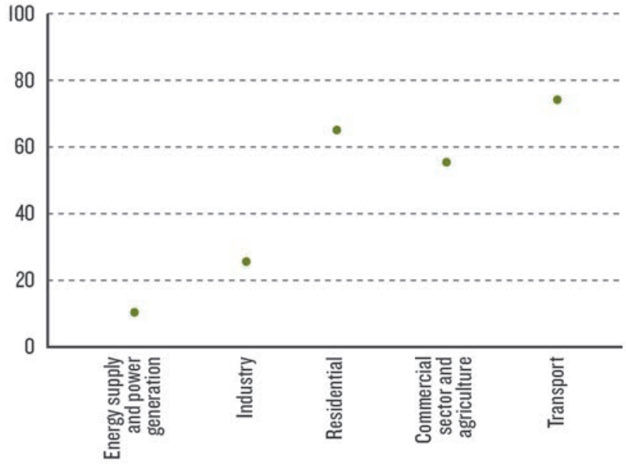
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



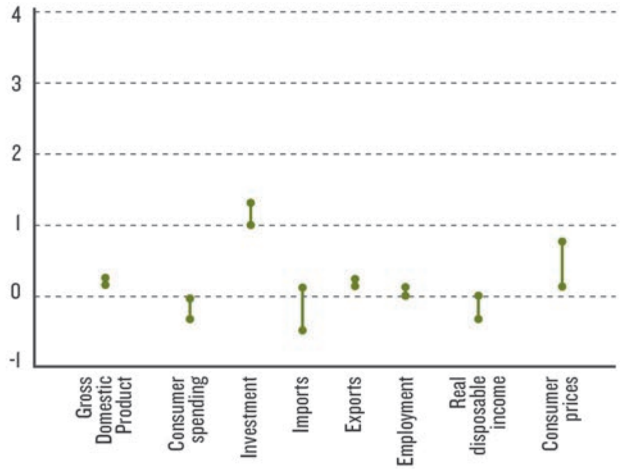
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



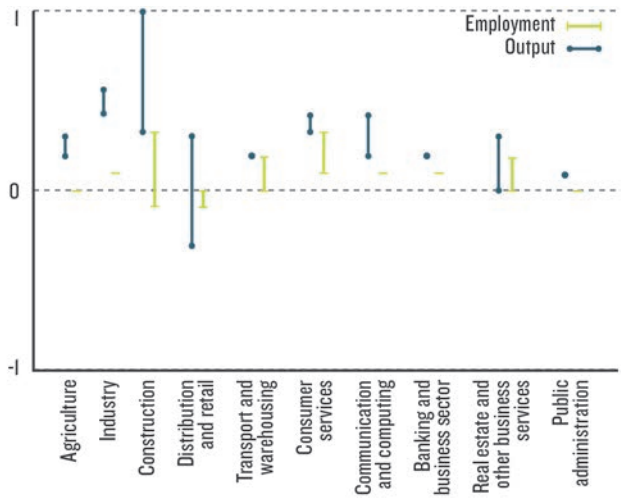
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



FRANCE

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

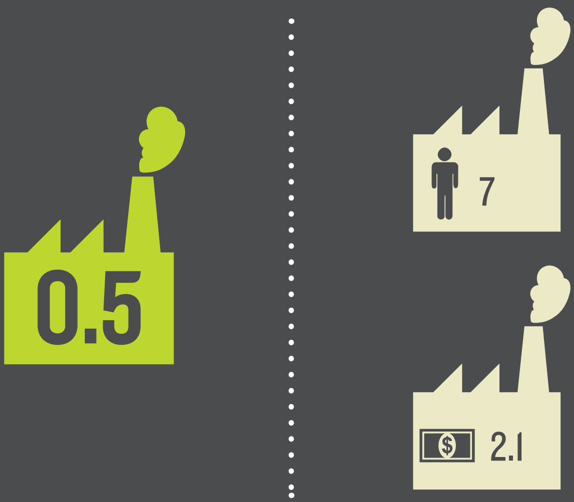
17 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 1.3 AND 1.5 PERCENT REDUCTION IN

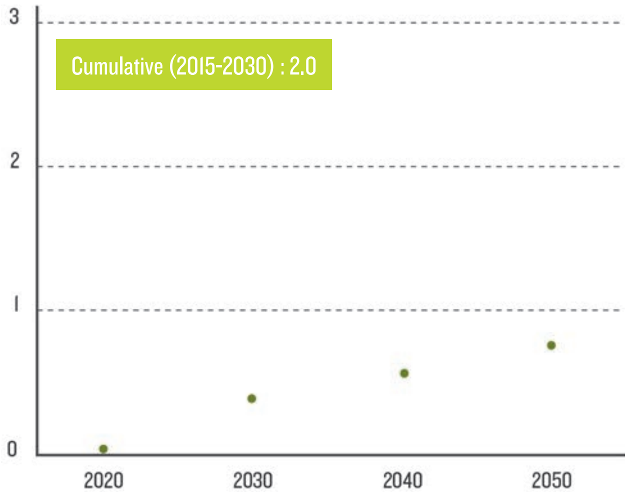
IMPORTS

COMPARED TO THE REFERENCE SCENARIO



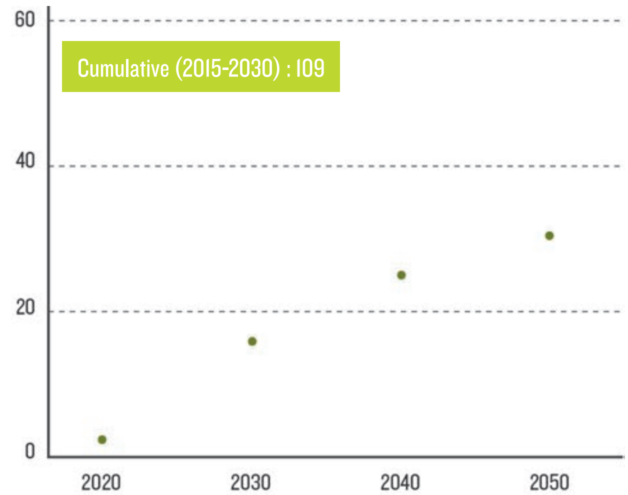
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



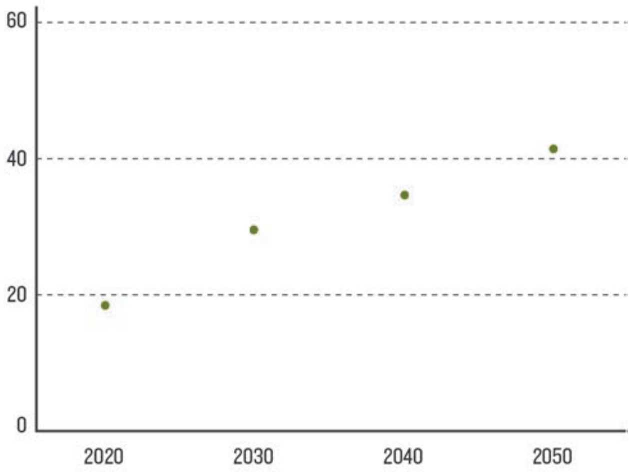
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



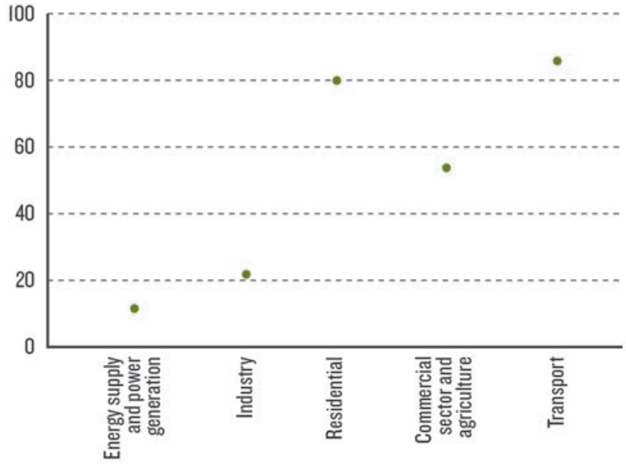
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



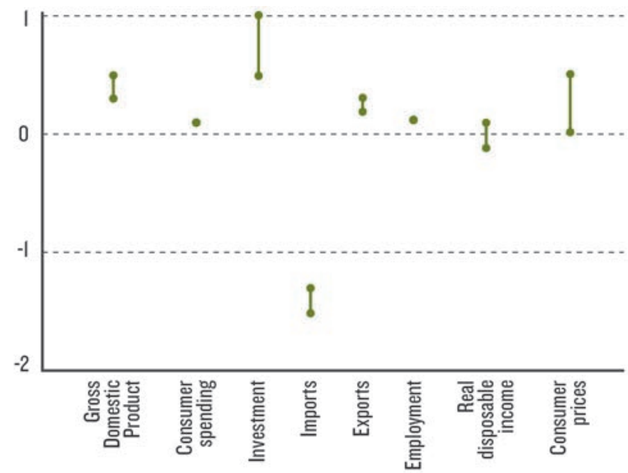
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



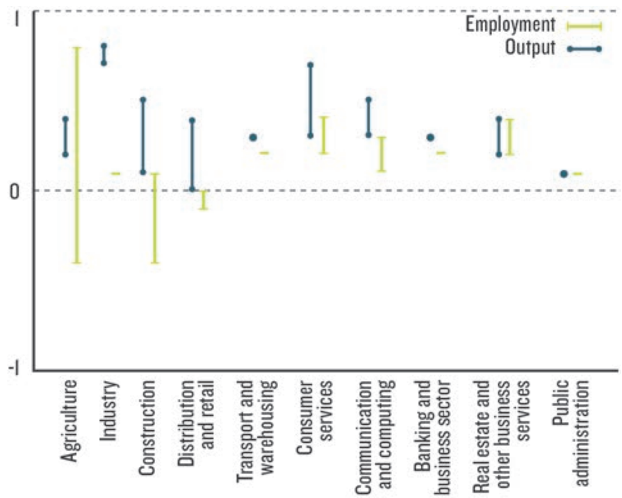
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



GERMANY

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

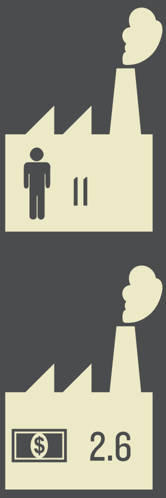
16 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

AN ESTIMATED 83 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE

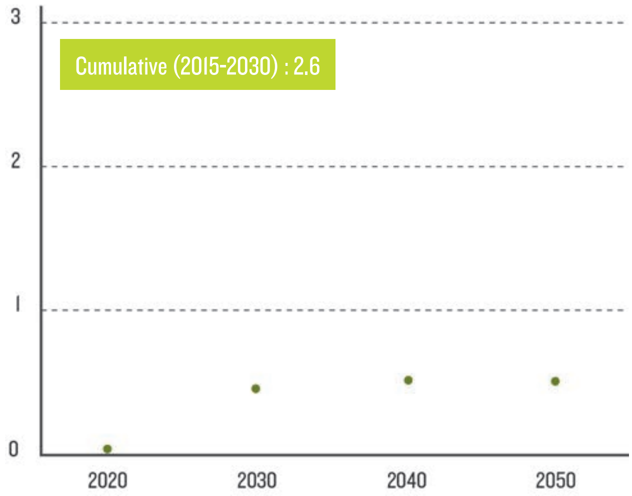
TRANSPORT SECTOR

WOULD BE ACHIEVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS



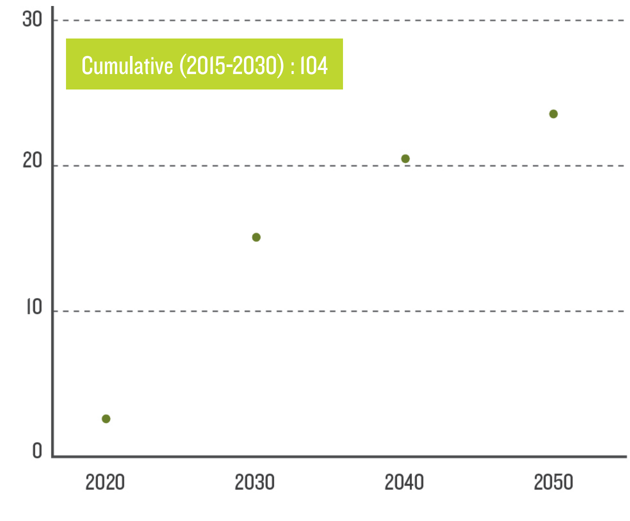
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



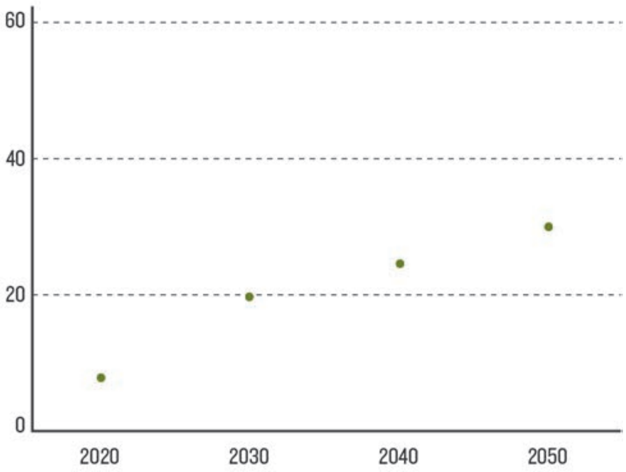
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



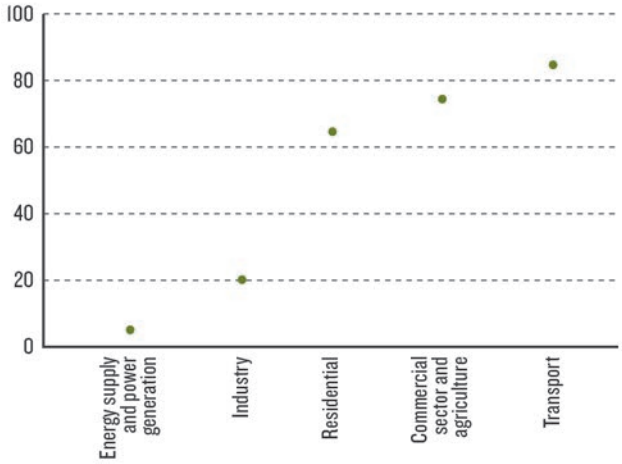
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



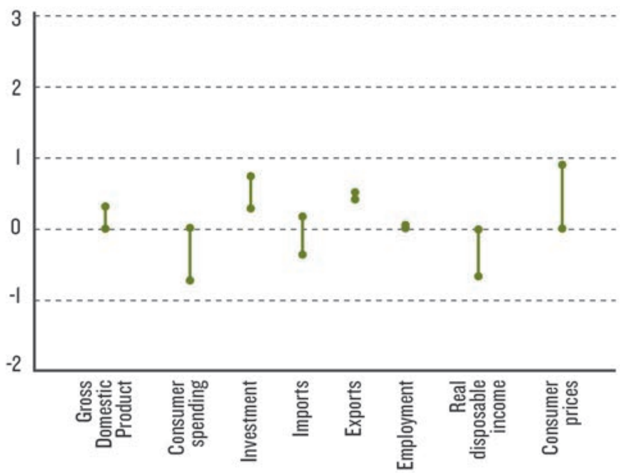
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



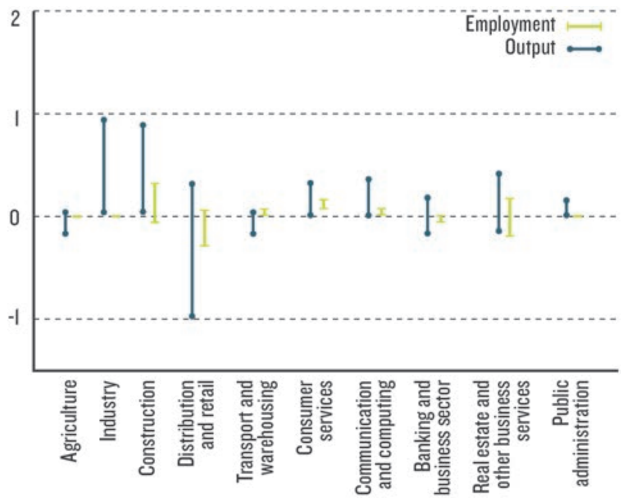
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



INDIA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

UP TO

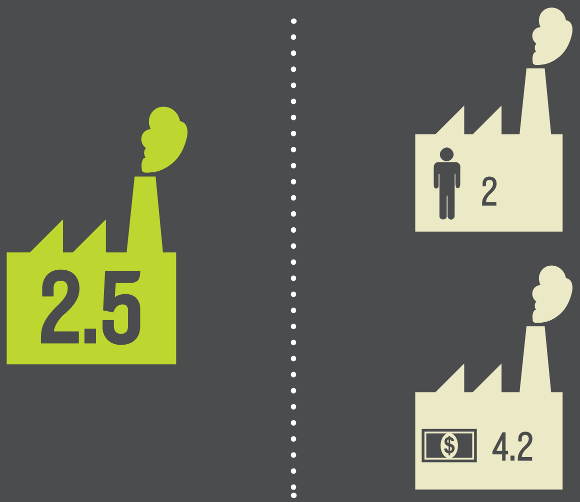
335 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY MEASURES

BETWEEN 0.6 AND 0.9 PERCENT
GROWTH IN OUTPUT IN THE

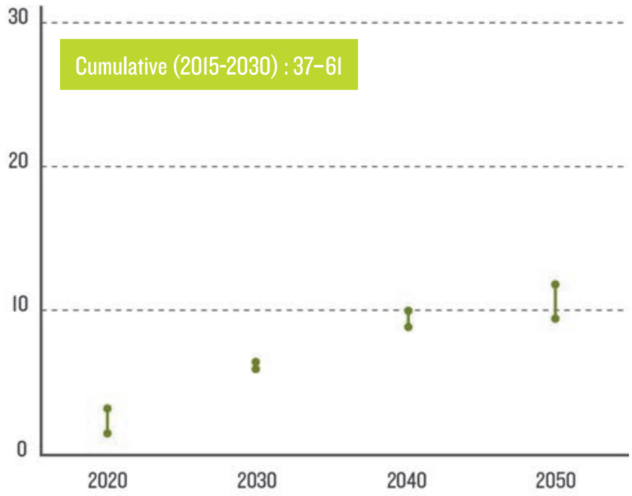
BANKING AND BUSINESS SECTOR

COMPARED TO THE REFERENCE SCENARIO



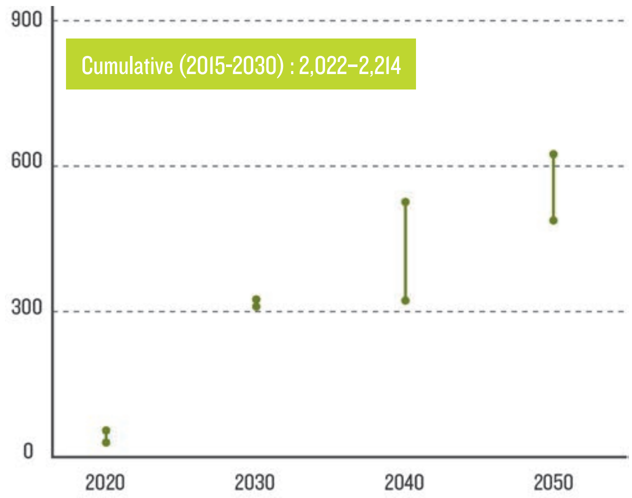
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



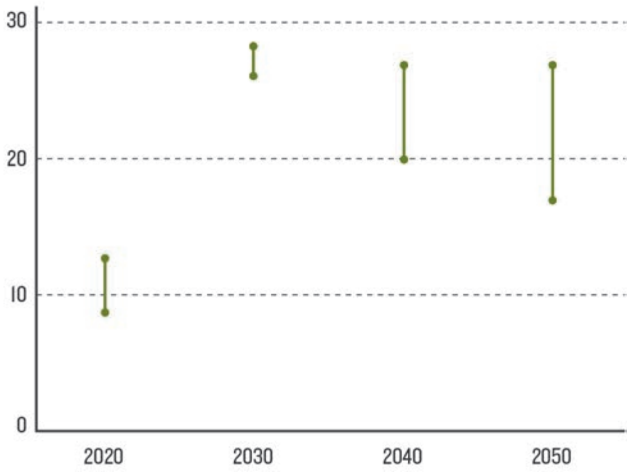
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



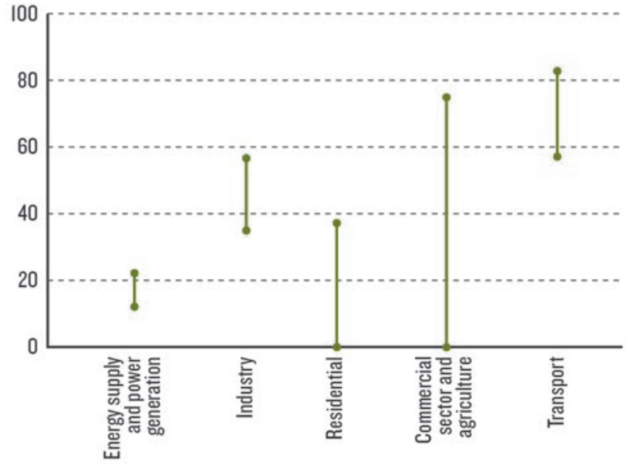
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



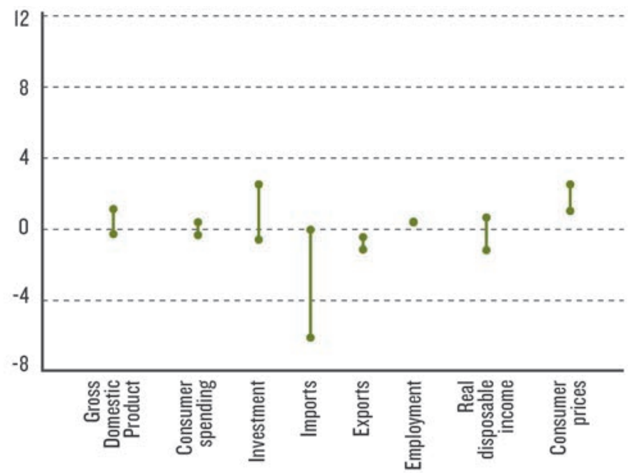
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



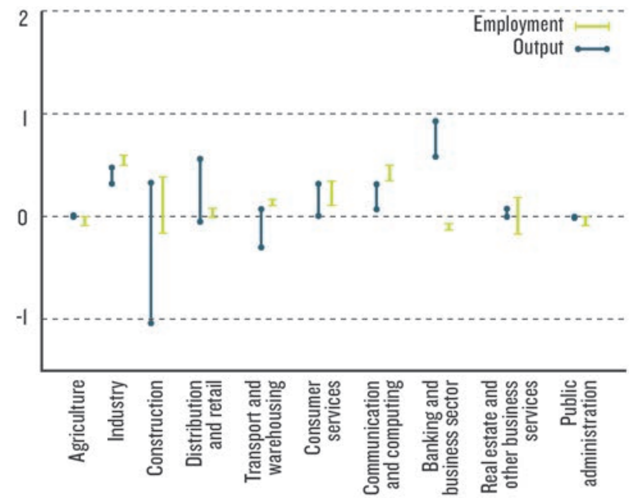
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



INDONESIA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST ABOVE

94 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

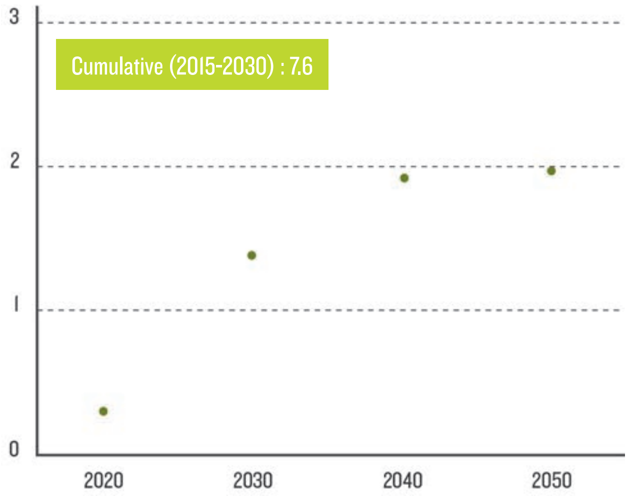
BETWEEN 1.1 AND 2.2 PERCENT GROWTH
IN SECTORAL OUTPUT IN THE

DISTRIBUTION AND RETAIL SECTOR

COMPARED TO THE REFERENCE SCENARIO

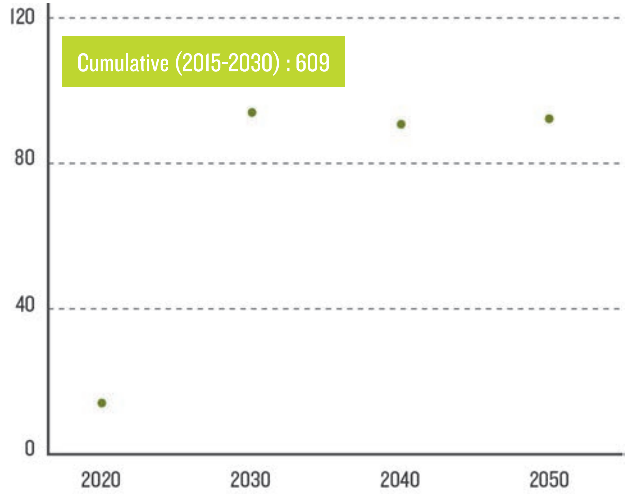
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



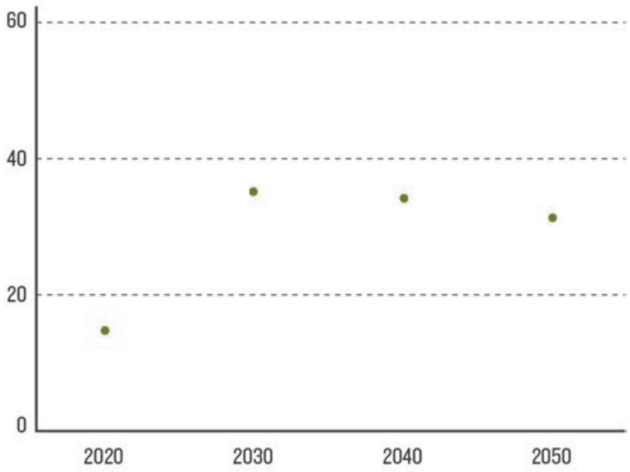
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



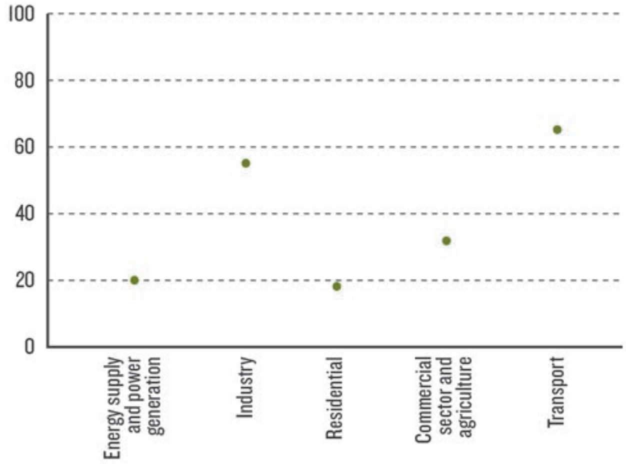
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



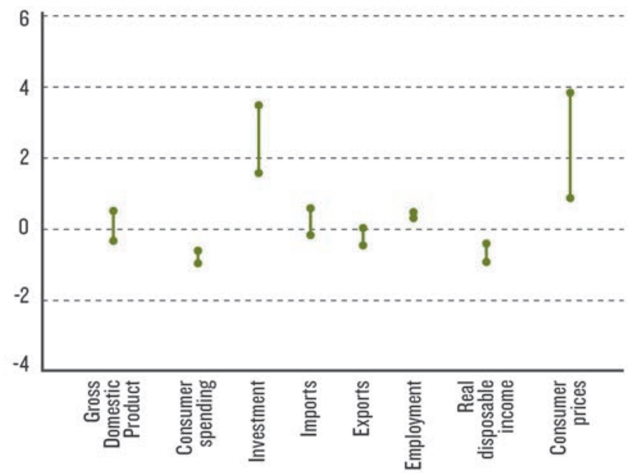
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



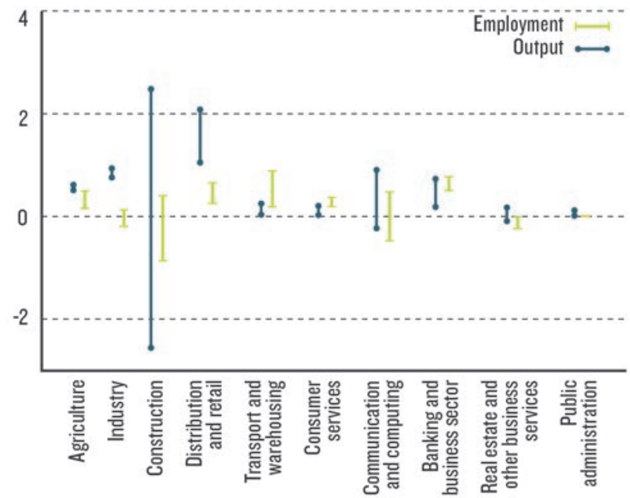
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



ITALY

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

9 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

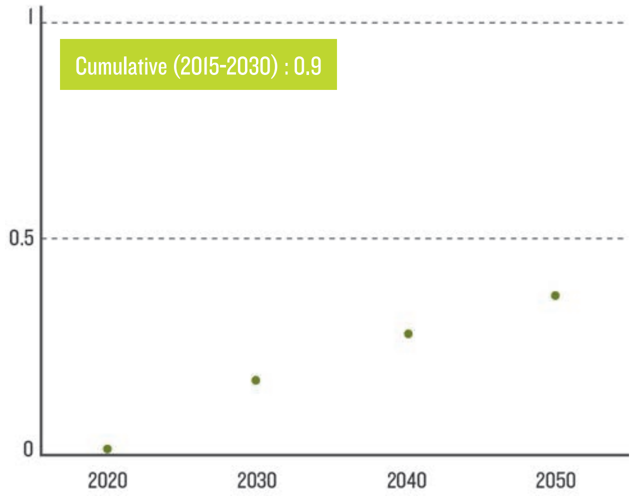
BETWEEN 1 AND 1.1 PERCENT GROWTH IN

INVESTMENT

COMPARED TO THE REFERENCE SCENARIO

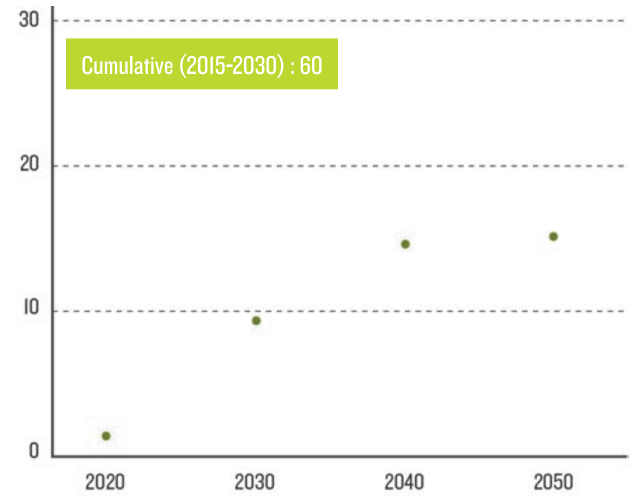
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



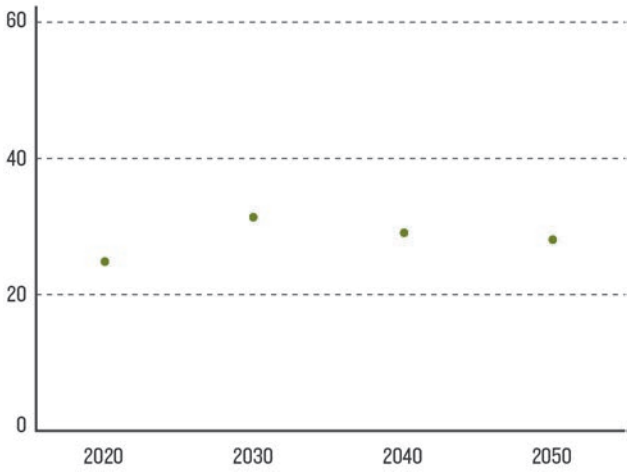
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



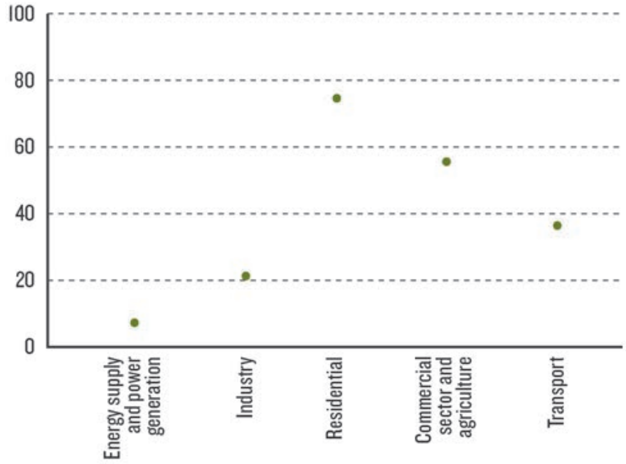
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



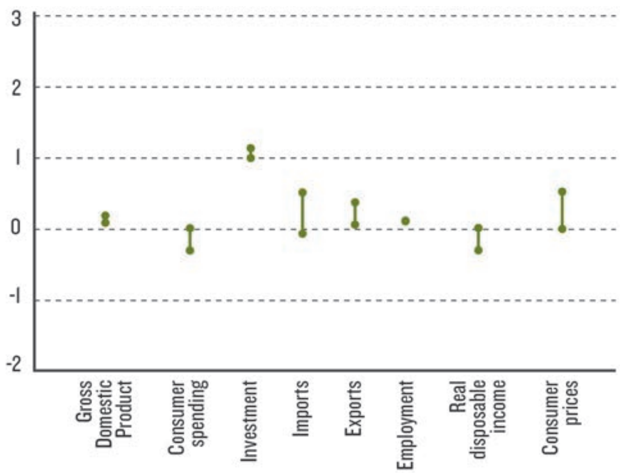
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



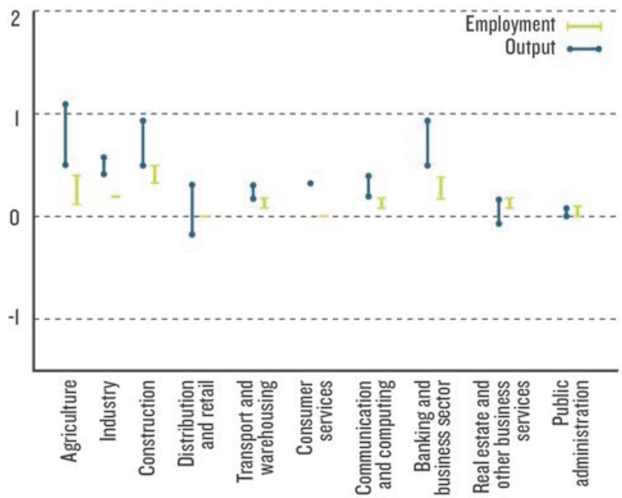
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



JAPAN

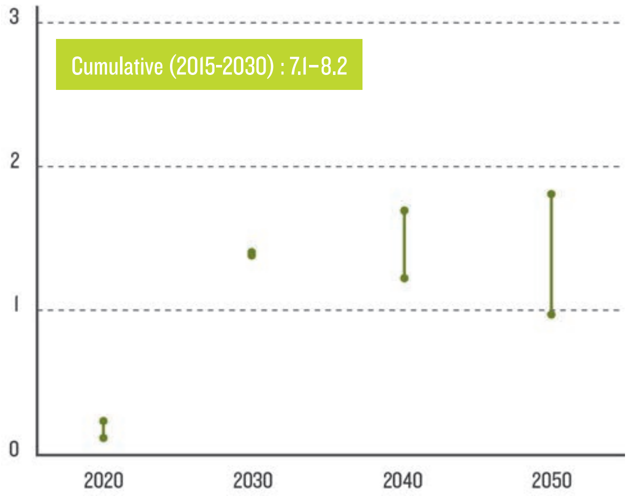
IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

UP TO
1.3 EJ
SAVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 0.5 AND 0.9 PERCENT REDUCTION IN
IMPORTS
COMPARED TO THE REFERENCE SCENARIO

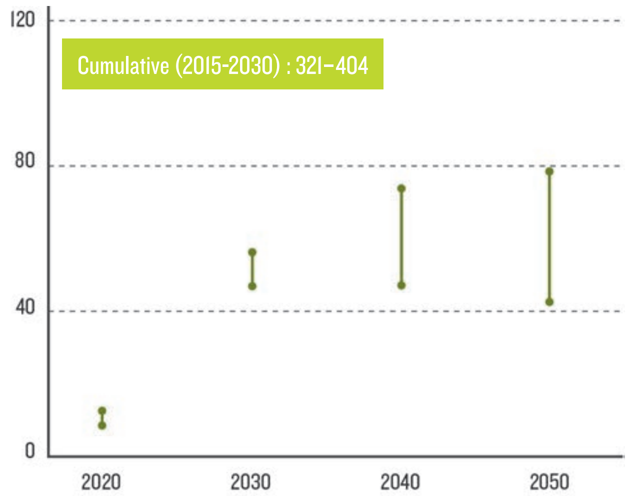
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



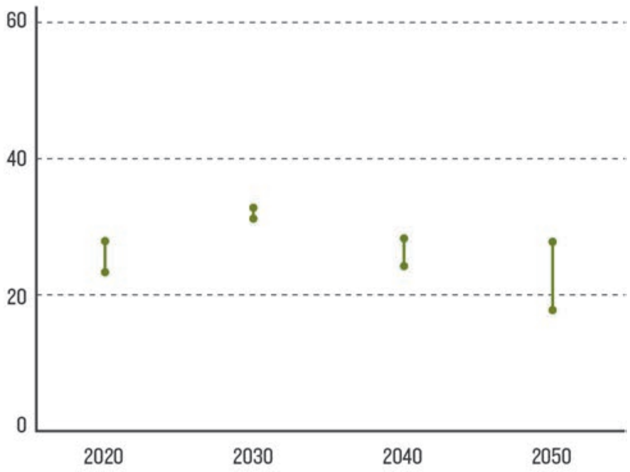
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



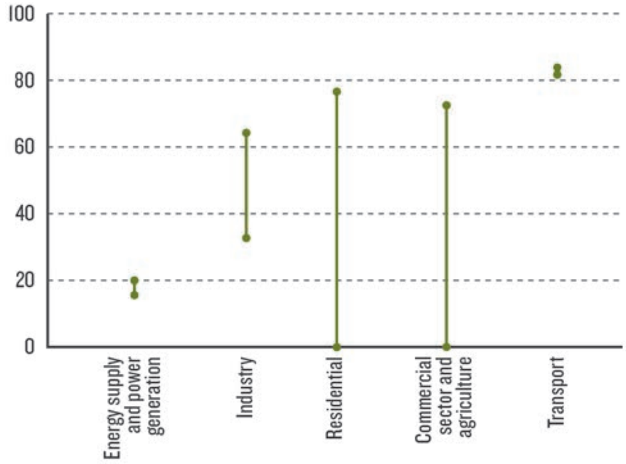
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



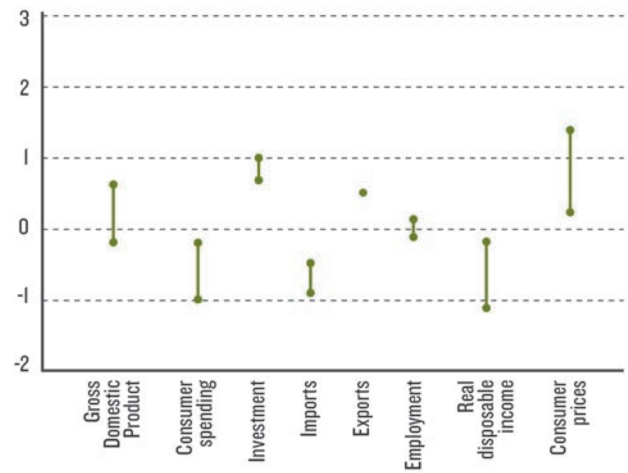
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



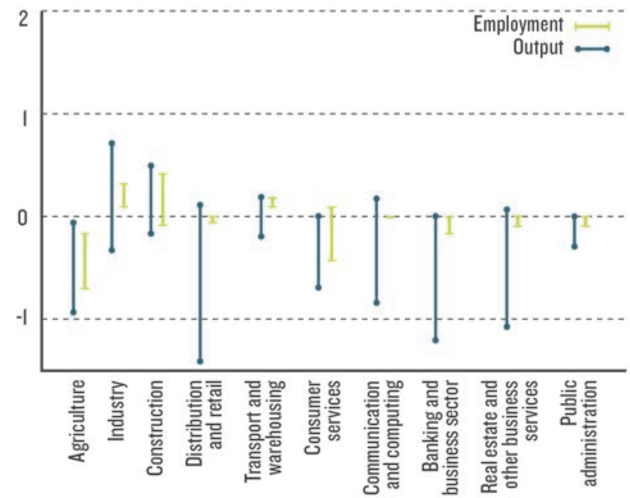
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



MEXICO

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

BETWEEN

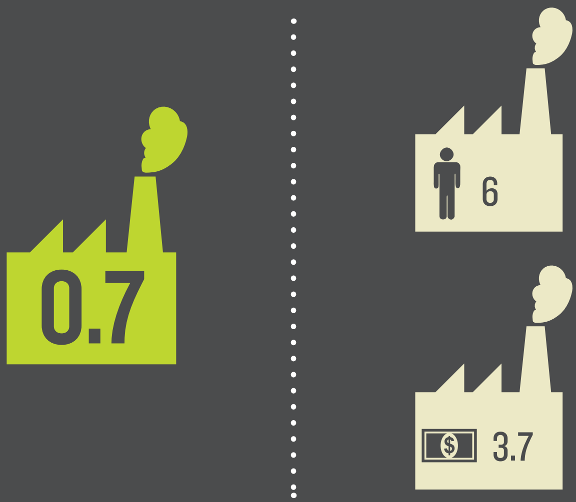
21 AND 29 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 0.3 AND 0.8 PERCENT INCREASE IN

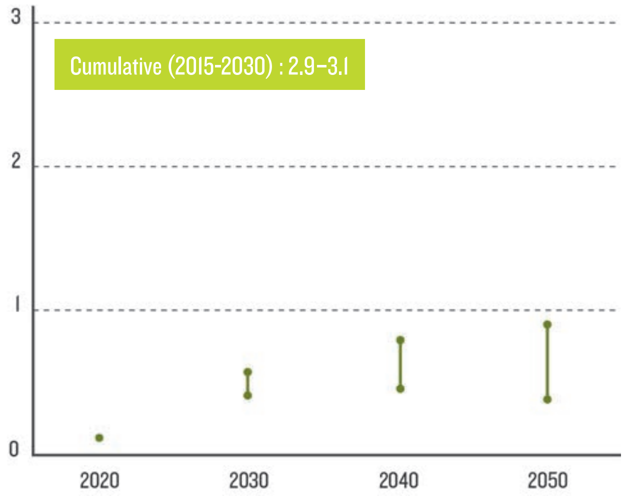
EXPORTS

COMPARED TO THE REFERENCE SCENARIO



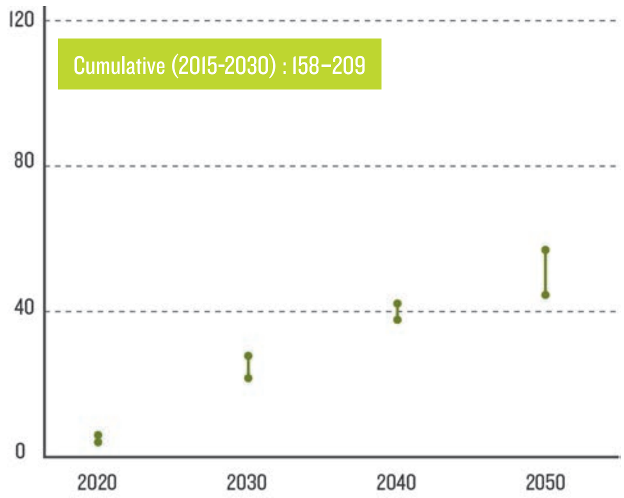
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



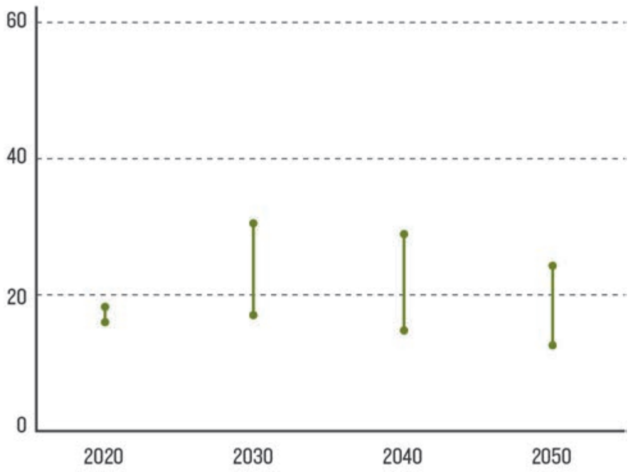
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



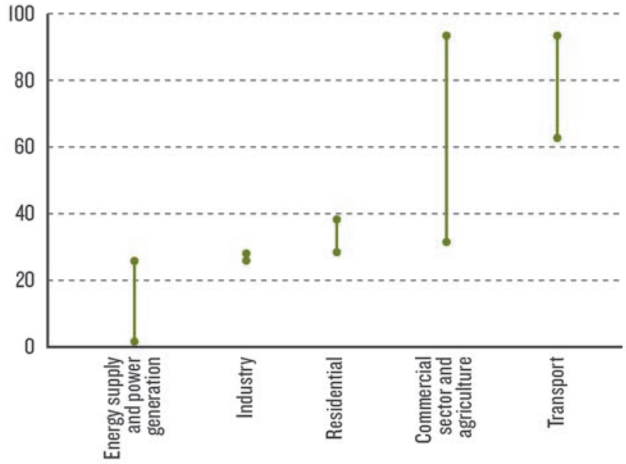
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



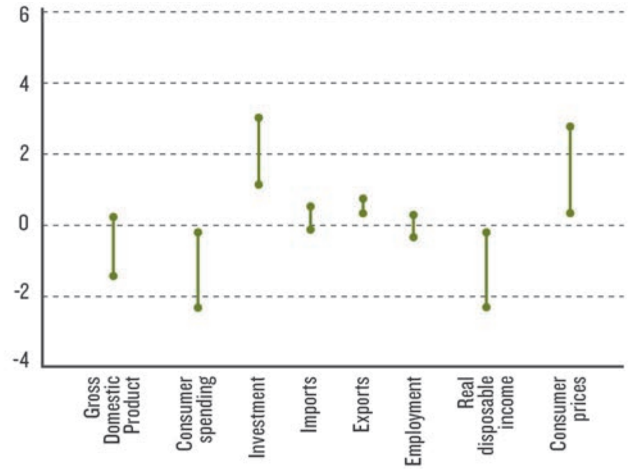
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



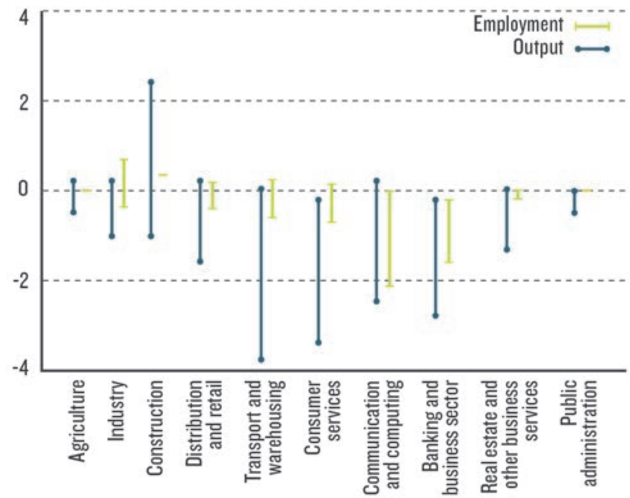
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



REPUBLIC OF KOREA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

BETWEEN

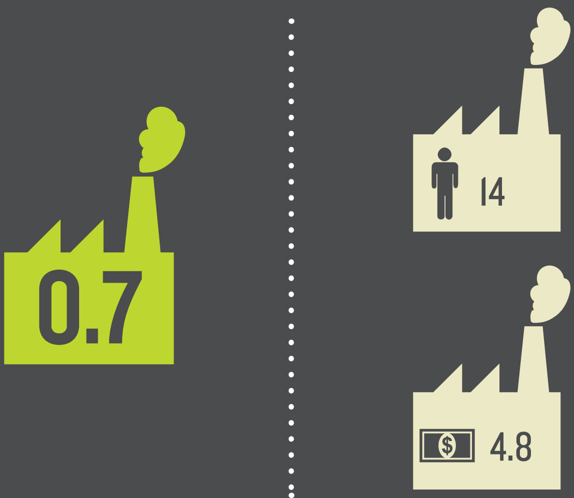
20 AND 34 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 84 AND 94 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE

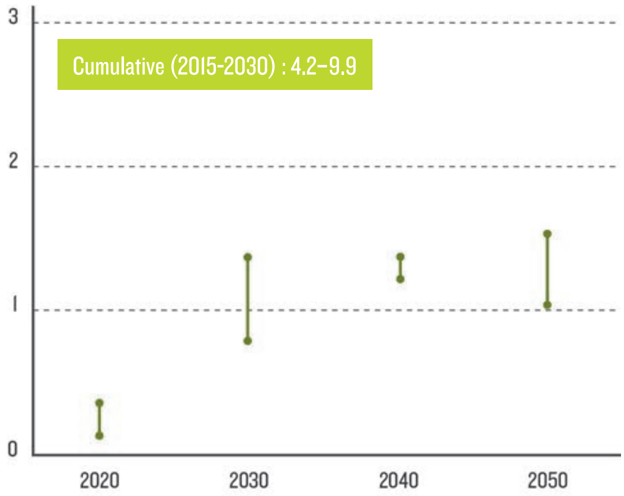
TRANSPORT SECTOR

WOULD BE ACHIEVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS



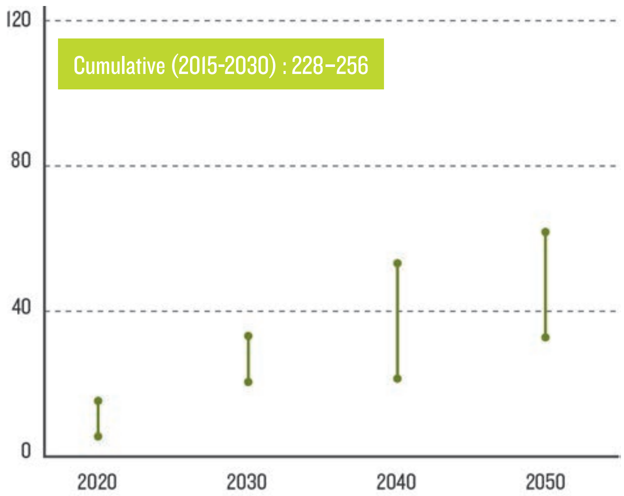
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



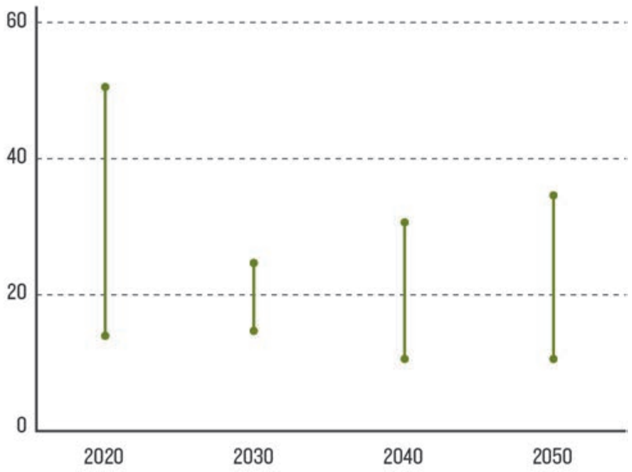
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



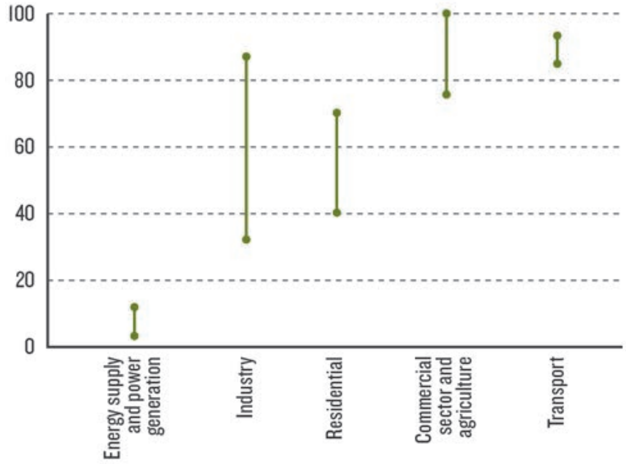
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



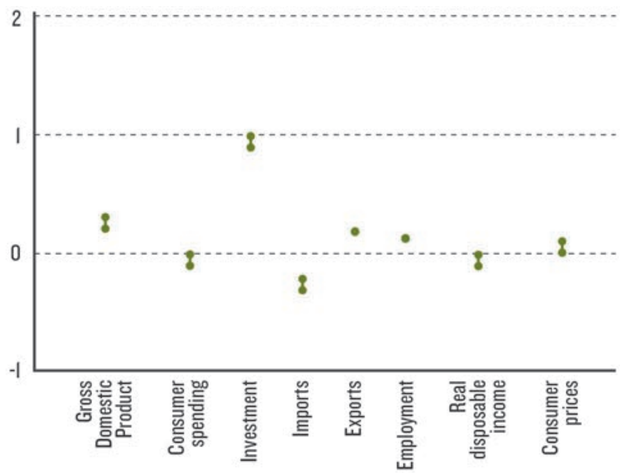
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



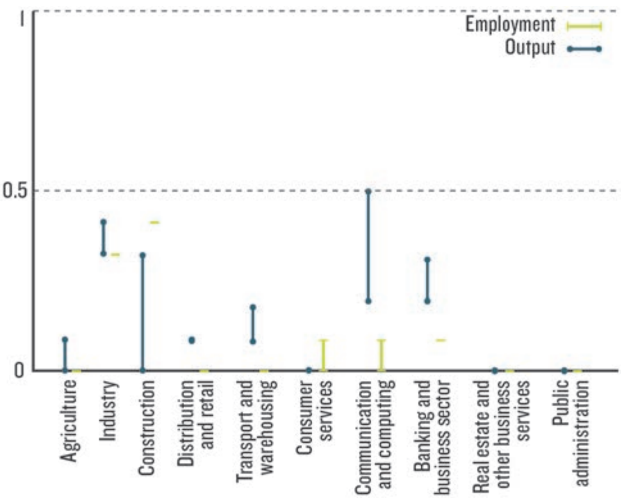
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



RUSSIA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST ABOVE

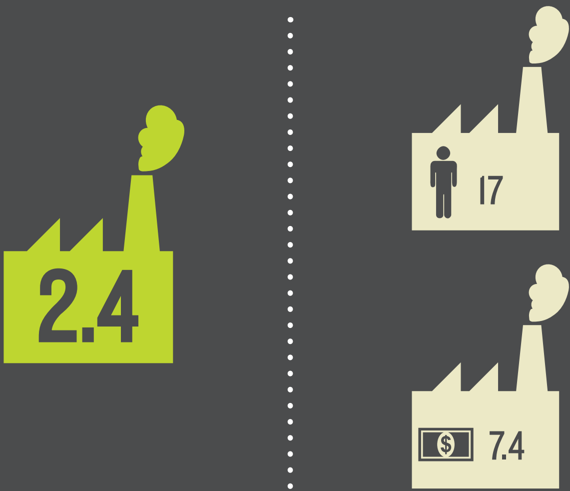
210 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 1 AND 4.1 PERCENT REDUCTION IN

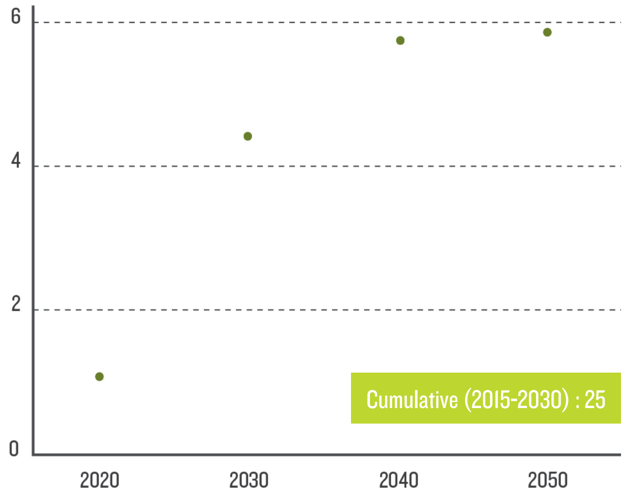
EXPORTS

COMPARED TO THE REFERENCE SCENARIO



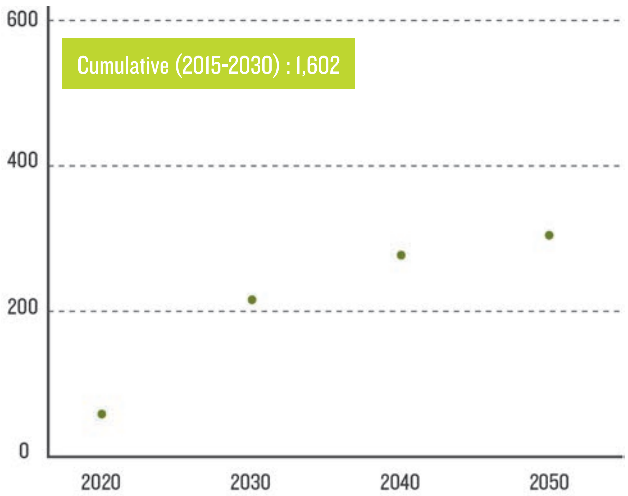
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



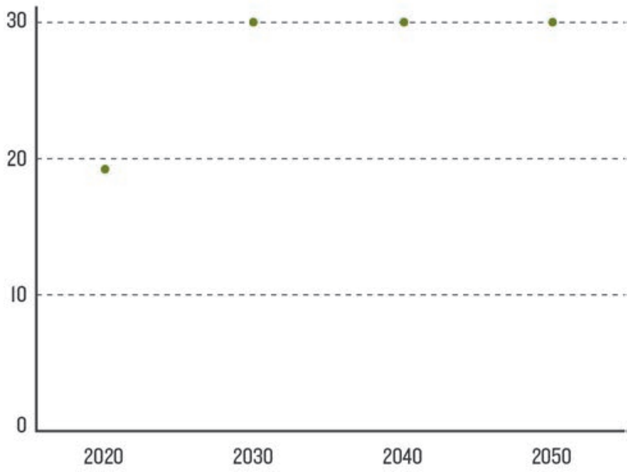
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



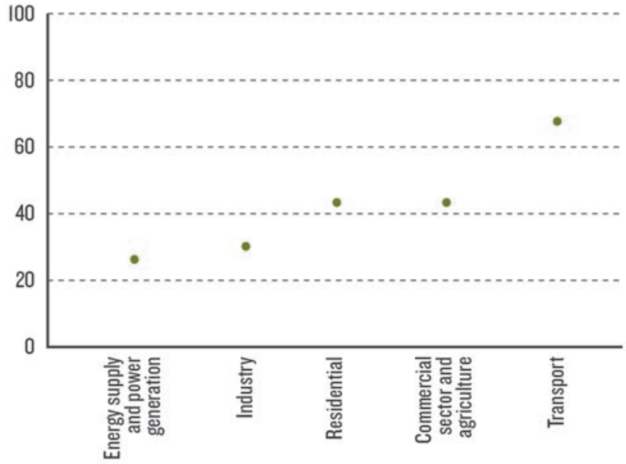
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



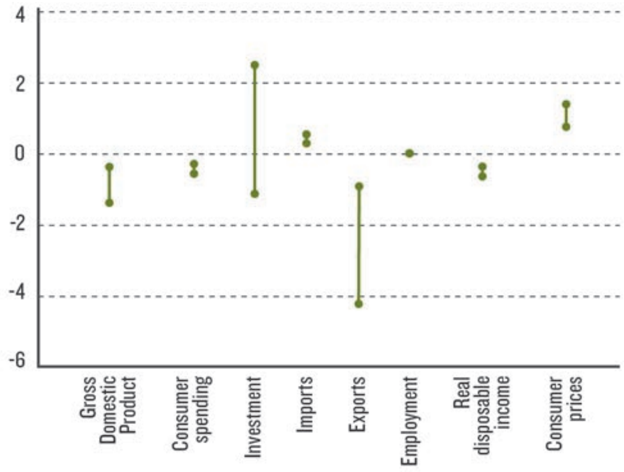
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



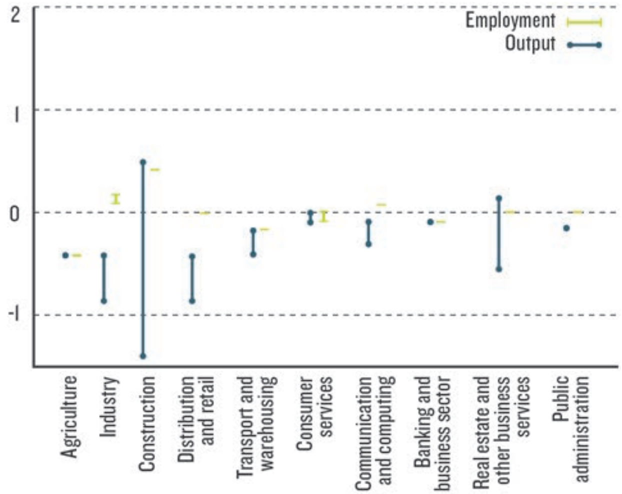
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



SOUTH AFRICA

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST ABOVE

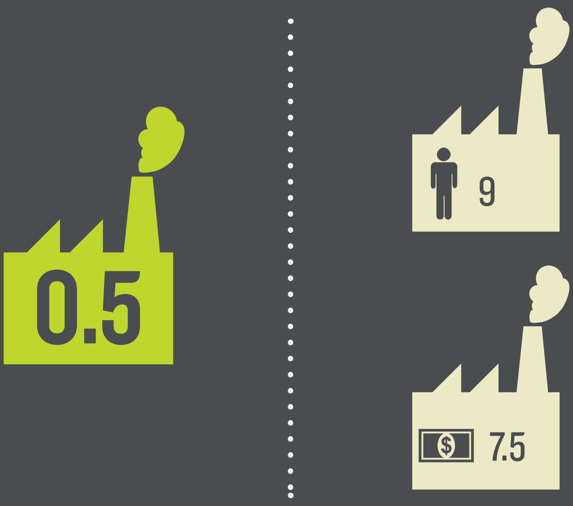
57 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

AN ESTIMATED 47 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE

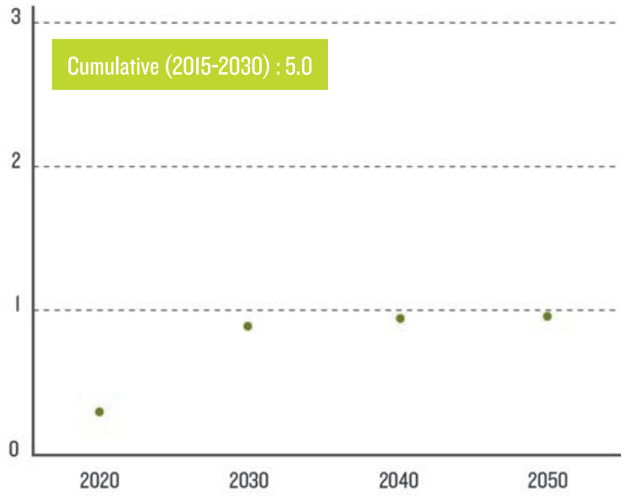
INDUSTRY SECTOR

WOULD BE ACHIEVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS



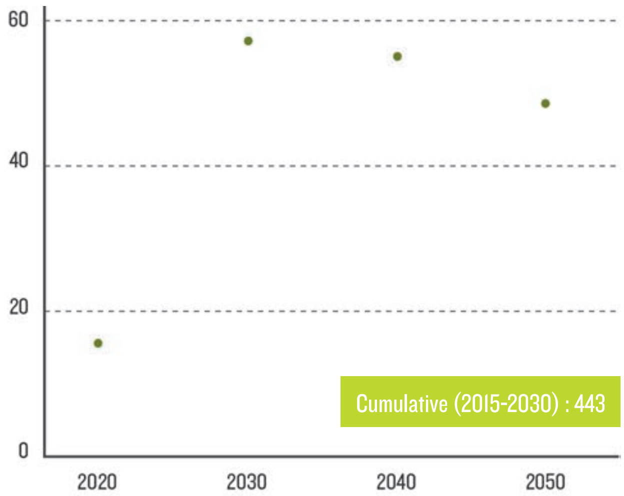
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



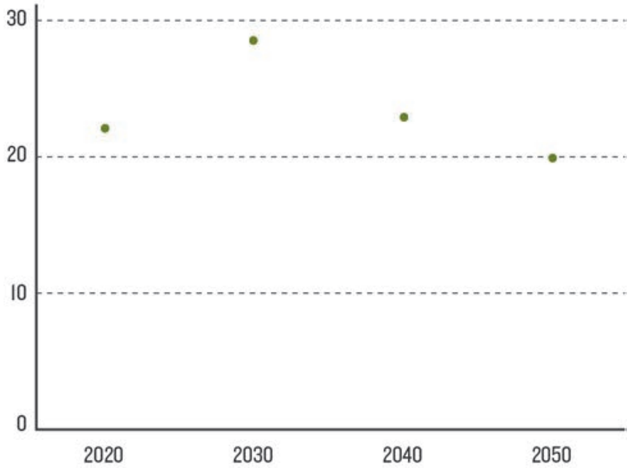
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



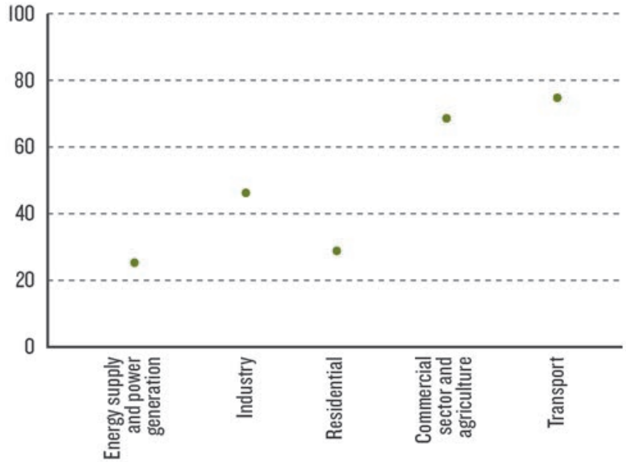
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact

NO ESTIMATES AVAILABLE

Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector

NO ESTIMATES AVAILABLE

TURKEY

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

JUST BELOW

28 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

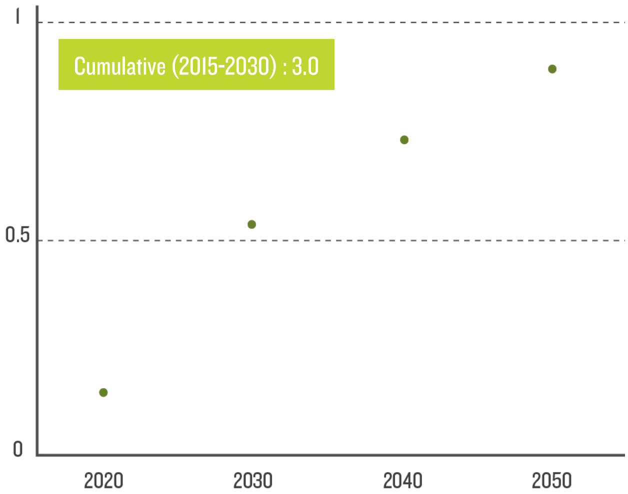
AN ESTIMATED 65 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE

INDUSTRY SECTOR

WOULD BE ACHIEVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

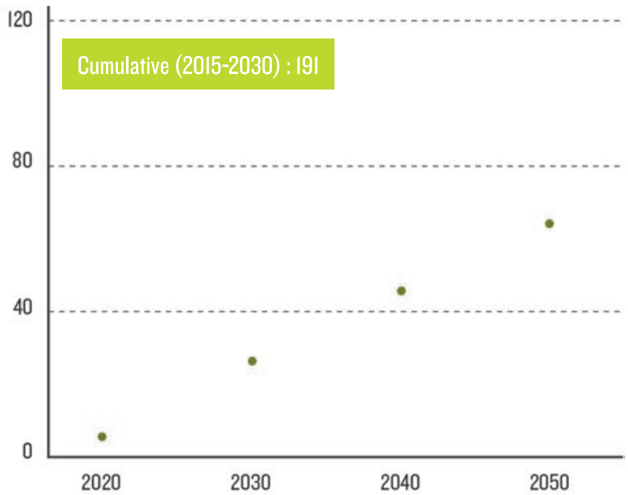
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



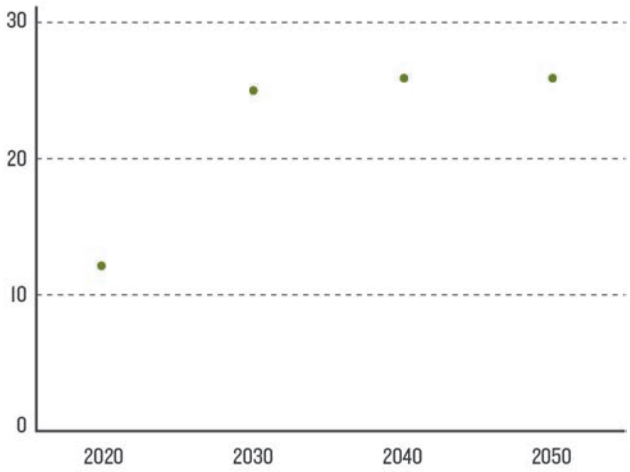
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



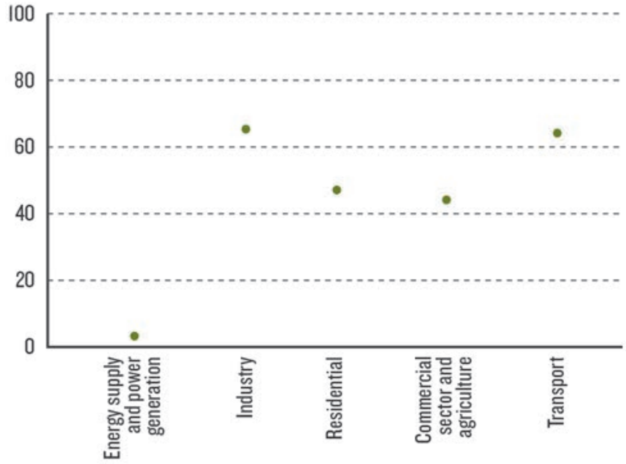
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



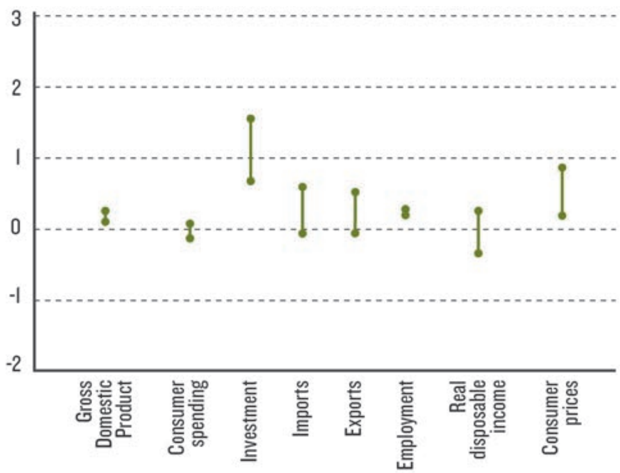
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



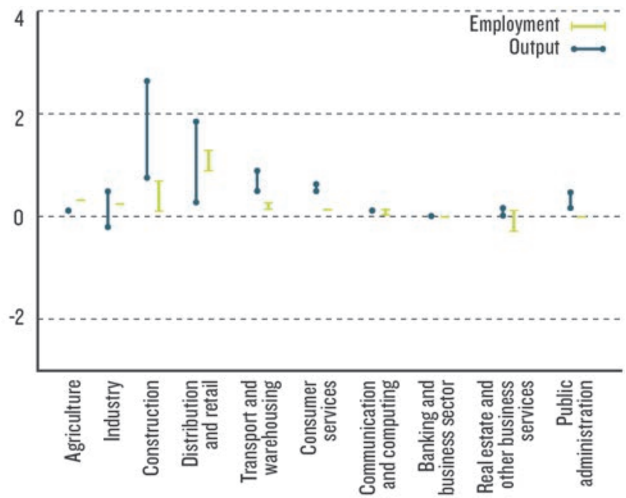
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



UNITED KINGDOM

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

AN ESTIMATED

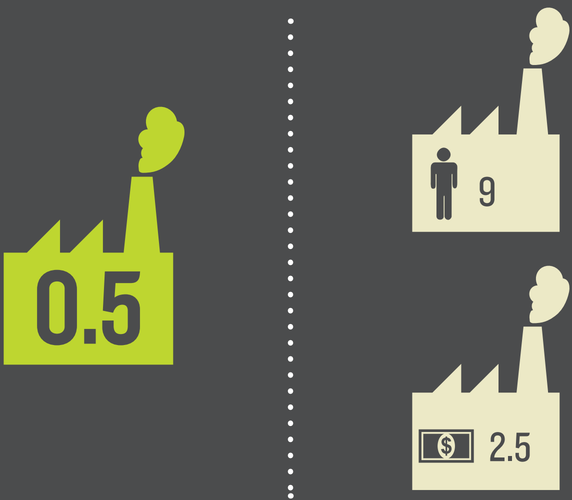
17 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

AN ESTIMATED 75 PERCENT OF ALL ECONOMICALLY EFFICIENT EMISSION REDUCTIONS IN THE

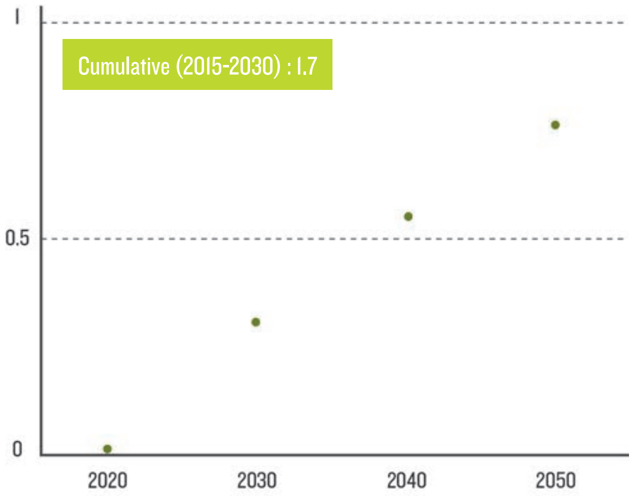
BUILDING SECTOR

WOULD BE ACHIEVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS



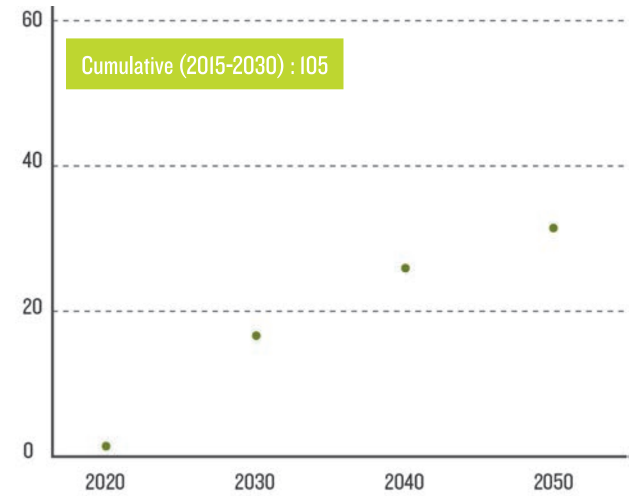
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



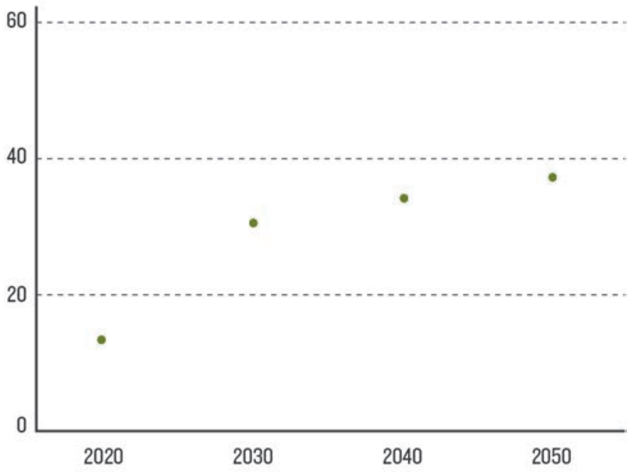
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



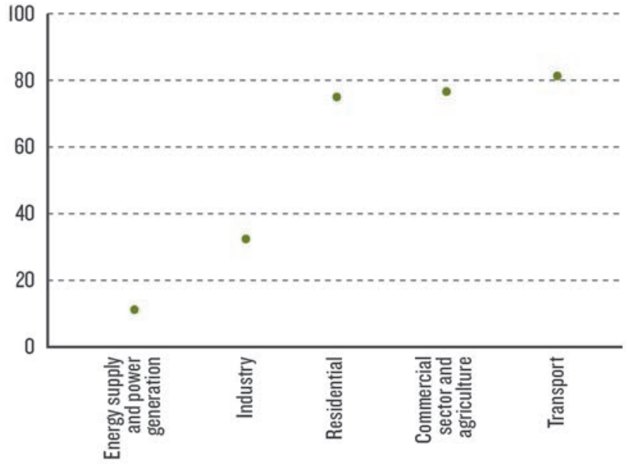
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



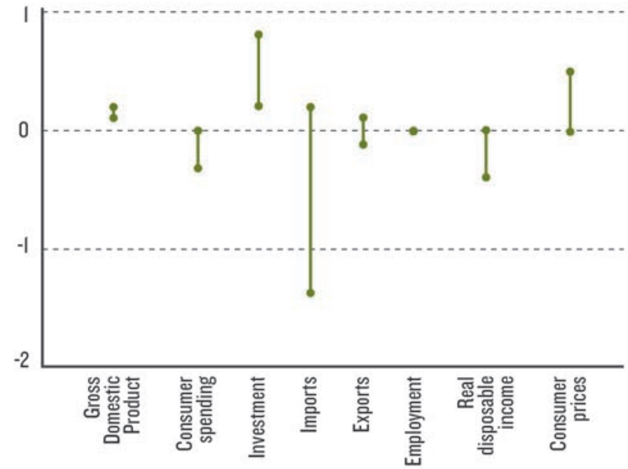
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



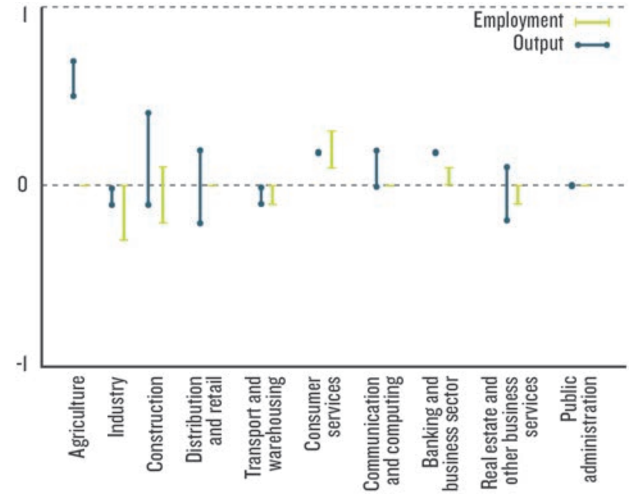
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



UNITED STATES

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

BETWEEN

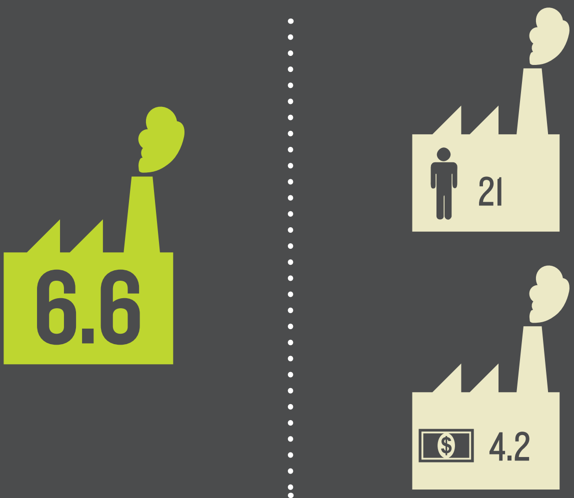
7.6 AND 8.6 EJ

SAVED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

BETWEEN 1.5 AND 3.5 PERCENT GROWTH IN

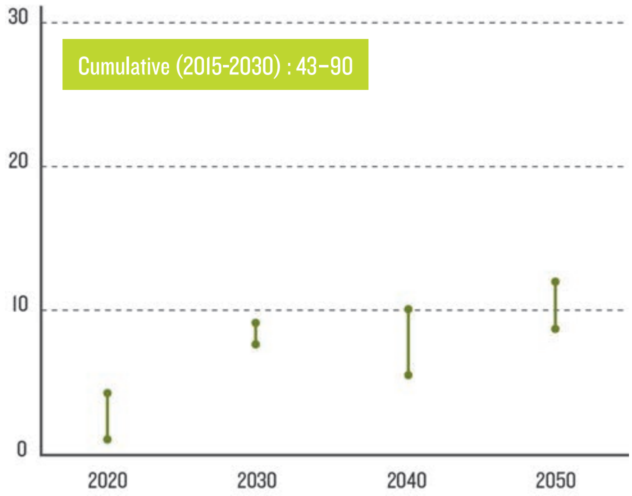
INVESTMENT

COMPARED TO THE REFERENCE SCENARIO



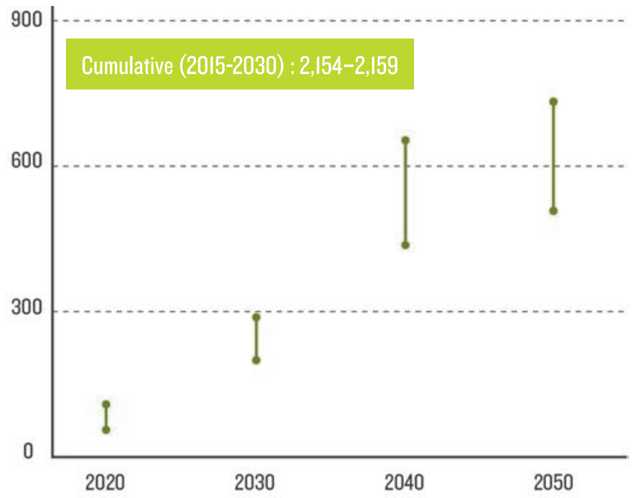
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



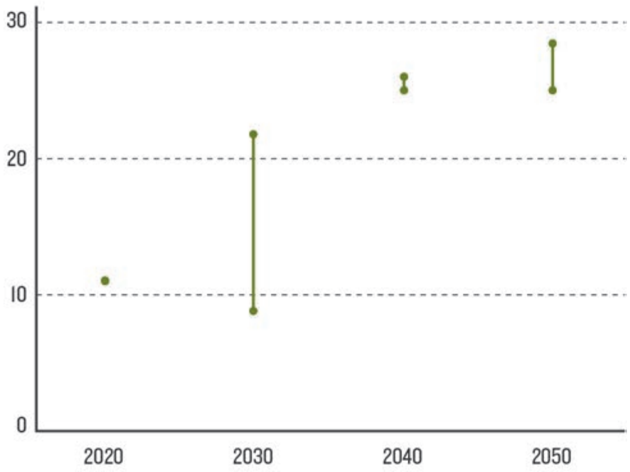
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



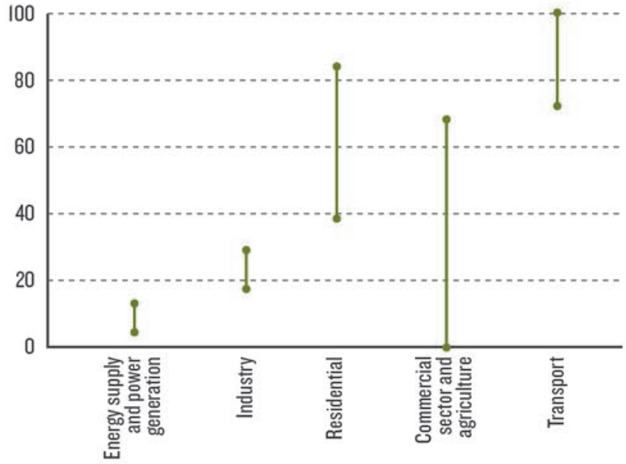
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



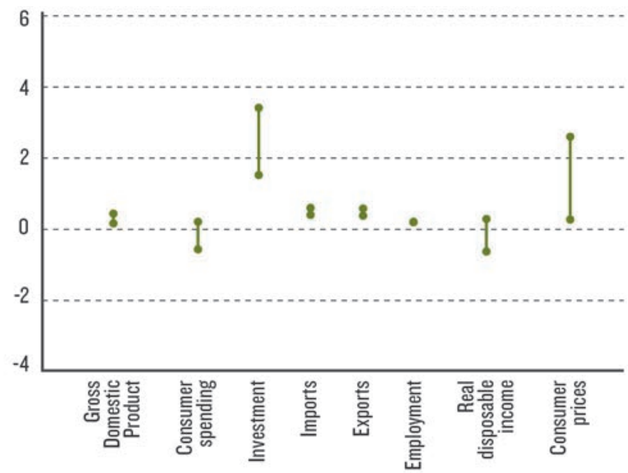
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



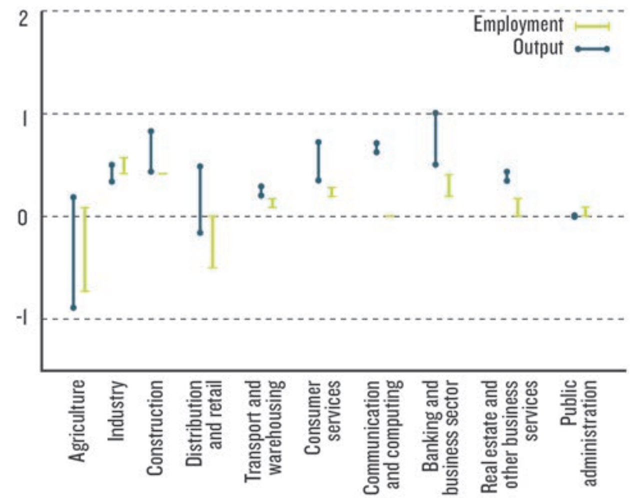
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



WORLD

IN THE USD 70 SCENARIO, ANNUALLY IN 2030:

BETWEEN

2.6 AND 3.3 $MtCO_2e$

REDUCED THROUGH
ENERGY EFFICIENCY IMPROVEMENTS

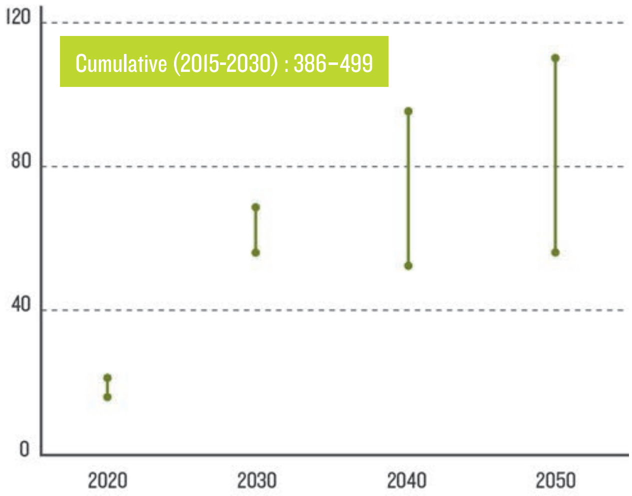
BETWEEN 1.8 AND 2.1 PERCENT GROWTH IN

INVESTMENT

COMPARED TO THE REFERENCE SCENARIO

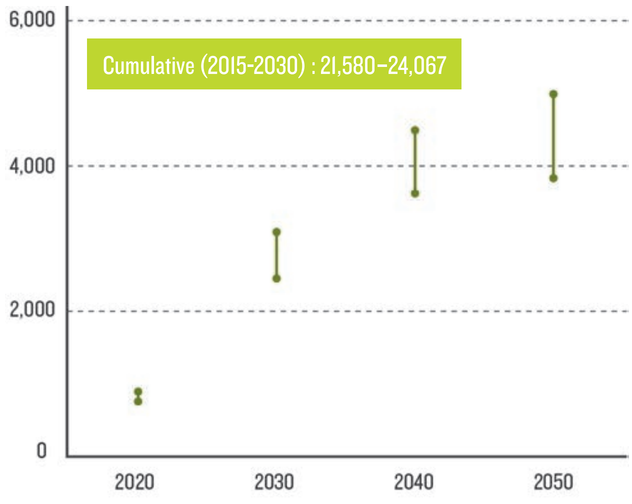
Primary energy demand reductions associated with improvements in energy efficiency (EJ)

For a price of USD 70 per tonne of carbon



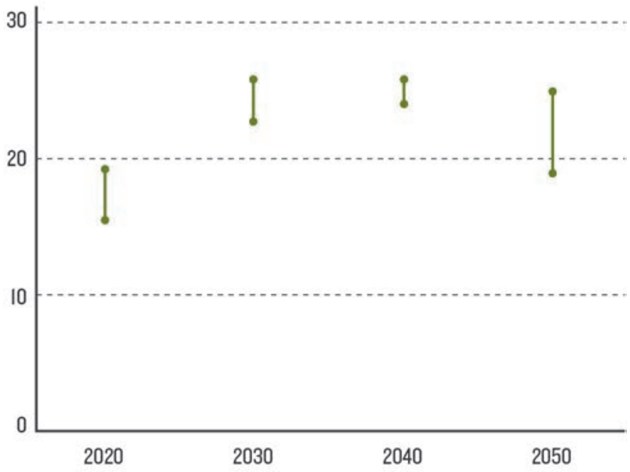
Greenhouse gas emission reductions associated with improvements in energy efficiency ($MtCO_2e$)

For a price of USD 70 per tonne of carbon



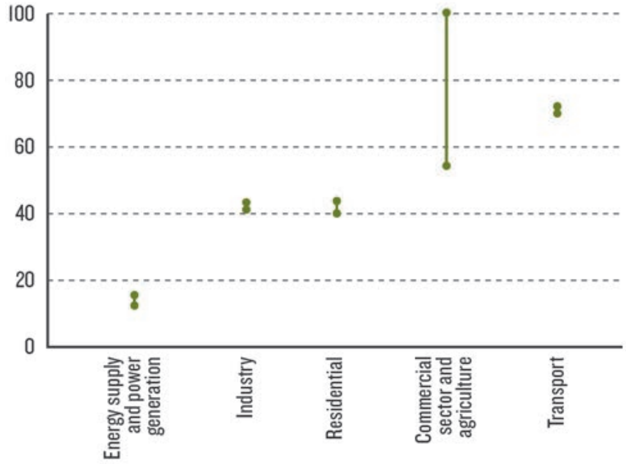
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

For a price of USD 70 per tonne of carbon, by year



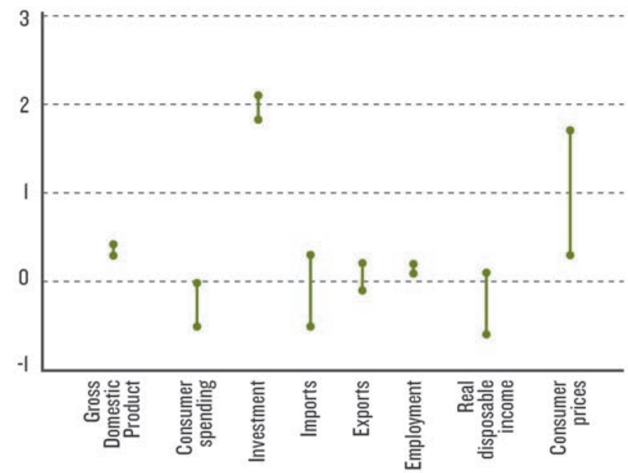
Greenhouse gas emission reductions associated with improvements in energy efficiency, compared to total economic emissions reductions and relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



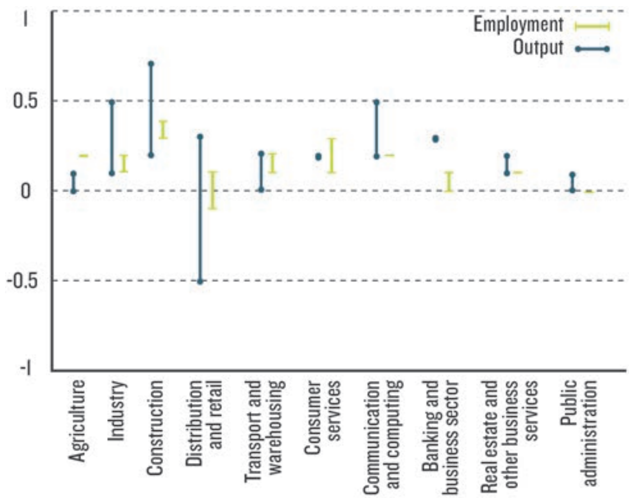
Macro-economic impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by type of impact



Ouput and employment impacts relative to the reference scenario (percent)

In 2030, for a price of USD 70 per tonne of carbon, by sector



ANNEX 5

SUMMARY OF POLICY APPROACHES SURVEYED

The following pages summarize the results of a survey of twenty-five national programmes affecting energy efficiency, covering eight diverse areas: building efficiency, car-scrapping, demand-side management, financial inducements, performance benchmarking, policy frameworks, standards and labels, and voluntary agreements.

For each area, three national programmes were surveyed (four, in one instance). For each programme, information was collected with regard to the following topics:

- objective of the programme;
- type of instrument(s) used to achieve the objective;
- actors involved and their respective roles;
- barriers to and enablers for programme implementation;
- costs of the programme by cost element;
- sources of funding; and
- energy savings and associated reductions in greenhouse gas emissions.

In addition, the benefits of the programme were estimated, including:

- reductions in energy use,
- reductions in greenhouse gas emissions,
- improvements in air quality,
- macro-economic impacts,
- impacts on public budgets,
- creation of jobs,
- improvements in human health and well-being,
- increased access to energy and reduced fuel poverty, and
- benefits to energy providers.

Information was sourced from existing evaluations (where available) and from direct contacts with key programme actors. Significant efforts went into ensuring that respondents across sectors and countries had a shared understanding of the information being requested from them, to increase the comparability of the results.

Full case studies are included in a technical report, a summary of which is also available online. Both reports can be accessed online at http://www.unepdtu.org/.

BUILDING EFFICIENCY

SCOPE OF THE CASES SURVEYED

Reducing energy use in existing buildings and supporting the construction of new buildings that meet certain minimum energy-efficiency standards

INSTRUMENT USED

Instrument used. Financial incentives, in the form of soft loans (Germany) or grants (Germany, Sweden and United States) and information dissemination and training activities to complement the financial schemes (Germany, Sweden and United States)

BARRIERS TO IMPLEMENTATION

- **Information dissemination:** no synthesis of lessons learnt (Sweden), inability to reach all actors and regions (Sweden) and inability to keep track with technology innovation (United States)
- **Governance inconsistencies:** newer, more ambitious federal policy initiatives, and less stringent regional policies that may undermine the goals of the programme (Germany)
- **Finance levels:** a fuller coverage of costs would have attracted more participants (United States)

ENABLERS FOR IMPLEMENTATION

- **Legal requirement:** utilities had to comply with regulation requiring them to reduce energy use (United States)
- **Appropriate incentives:** finance sector actors were offered a range of incentives that justified their involvement and increased their competitiveness (Germany)
- **Confidence and credibility:** involvement of independent experts throughout the project cycle facilitated all aspects of programme implementation (Germany)
- **Increased competitiveness:** participants gained competitive advantage over their peers and developed a valued closer relationship with public authorities (Sweden)
- **Evaluation and revision:** the programme was revised to adjust incentives and promote new technologies that initially were not eligible (United States)

BENEFITS

- **Energy savings:** 2,200 GWh in the period 2008-2010 (Germany), 274 GWh in 2012 (United States)
- **Emission reductions:** 0.8 Mt CO_2 in 2012 (Germany), 7.6 Mt CO_2 in the period 2006-2013 (United States)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** the implemented energy efficiency projects represent more than USD 926 million in lifetime savings (United States)
- **Impacts on public budgets:** positive effect (unquantified) due to tax income and social security contributions (Germany)
- **Creation of jobs:** 370,000 jobs created or preserved in 2012 (Germany), and increased hiring of contractors (unquantified) with expertise in energy efficiency retrofits (United States)
- **Improvements in human health and well-being:** information not available
- **Increased access to energy and reduced fuel poverty:** 1.8 million households with lower energy bills (Germany)
- **Benefits to energy providers:** awareness-raising about the benefits of energy savings in buildings (Sweden and United States)

CAR SCRAPPING

SCOPE OF THE CASES SURVEYED

Renewing motor vehicle fleets through consumption bolstering price stimuli aimed at retiring inefficient and unsafe vehicles, and reducing local air pollution

INSTRUMENT USED

Financial incentives, in the form of price rebates (China and Germany), direct subsidies (China and Egypt) and reduced vehicle-purchase tax rates (China and Germany)

BARRIERS TO IMPLEMENTATION

- **Awareness raising:** campaigns used media with which the target beneficiaries were unfamiliar (Egypt)
- **Price stimuli:** at the early stages of the programme, rebate levels were too low to attract eligible beneficiaries (China)
- **Administrative requirements:** procedures were cumbersome (China), time frames were too short (Germany), and pre-selected companies for mandatory vehicle maintenance were overbooked (Egypt)
- **Governance inconsistencies:** enforcement varied across regions, and local schemes had different requirements compared to the country-wide scheme (China)

ENABLERS FOR IMPLEMENTATION

- **Price stimuli:** the amount of the incentive was significant enough to entice eligible participants (Egypt and Germany), and the programme included additional financial benefits such as reduced insurance premiums and guarantees for local bank loans (Egypt)
- **Application procedures:** procedures were clear, with a one-stop-shop for eligible participants (Egypt and Germany)
- **Policy enforcement:** tightened-up enforcement procedures for vehicle emission standards increased the programme's appeal (China)

BENEFITS

- **Energy savings:** below 1 percent in 2010, compared to a reference situation (China), 0.6 million toe (forecast) over the period 2010-2019 (Egypt), average fuel economy levels improved by 0.6 percent (Germany)
- **Emission reductions:** below 1 percent in 2010, compared to a reference situation (China), between 1.3 and 2.3 Mt CO_2e (forecast) over the period 2010-2019 (Egypt), about 0.2 Mt CO_2 (forecast) over the period 2010-2030 (Germany)
- **Improvements in air quality:** emissions of air pollutants reduced by 1 percent annually (forecast) over the period 2010-2019 compared to a reference situation (Egypt), the vast majority of the vehicles scrapped were EURO 2 standard or lower (Germany)
- **Macro-economic impacts:** between 0.2 and 0.4 percent increase in gross domestic product (China), about 0.15 percent increase in gross domestic product (Germany)
- **Impacts on public budgets:** fuel subsidy expenditures reduced by USD 61 million due to energy savings (Egypt), public finance costs of USD 1,160 million (Germany)
- **Creation of jobs:** less than 0.01 percent increase in job creation in 2009, compared to a reference situation (China), some 10,500 direct and 1,000 indirect new jobs (Egypt)
- **Improvements in human health and well-being:** injury levels reduced by 1 percent in 2010 compared to a reference situation (Germany)
- **Increased access to energy and reduced fuel poverty:** information not available
- **Benefits to energy providers:** information not available

DEMAND-SIDE MANAGEMENT

SCOPE OF THE CASES SURVEYED

Smart metering (Austria and Vietnam) and financial incentives for upgrading technologies ranging from shower heads to industrial heat pumps (South Africa)

INSTRUMENT USED

Financial mechanisms, such as tariffs (Austria), subsidies (South Africa) and grants (Vietnam)

BARRIERS TO IMPLEMENTATION

- **Stakeholder buy-in:** energy sector actors were sceptical about the merits of smart metering (Austria), and potential beneficiaries had insufficient information (Vietnam)
- **Inadequate expertise:** programme managers lacked sufficient expertise on some key implementation aspects (South Africa and Vietnam)
- **Electricity prices:** low electricity prices, coupled with limited cost-consciousness, reduced the potential interest in the programme (Vietnam)
- **Privacy concerns:** perceived lack of privacy and concerns over data protection standards triggered new, complementary legislation (Austria)
- **Due diligence measures:** potential beneficiaries criticised the utility's programme management procedures (South Africa)

ENABLERS FOR IMPLEMENTATION

- **Training sessions:** programme managers were trained in key technical aspects of the programme (Vietnam)
- **Customer attention:** programme owners provided all necessary infrastructure (Vietnam) and adapted procedures and technology portfolios (South Africa) to respond to user needs
- **Economic analysis:** a governmental ex-ante analysis highlighted the net benefits of the programme and was used to justify it (Austria)
- **Experience sharing:** a domestic pilot project and lessons learnt from related experiences in other countries were used to frame the programme (Austria)

BENEFITS

- **Energy savings:** 3.5 percent reduction in electricity use and 7 percent reduction in gas use (forecasts), compared to the reference situation, for the period 2012-2019 (Austria), 56 percent reduction in households and 21 percent reduction in industry, compared to a reference situation, for 2011 (South Africa), and 496 GWh in 2010 (Vietnam)
- **Emission reductions:** 232 Mt CO_2 in 2012 (South Africa), 1 Mt CO_2 in the period 2004-2010 (Vietnam)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** benefits between USD 3.8 billion and USD 5.2 billion in 2010 (Austria), aggregate investment of USD 5.2 million in the period 2004-2010 (Vietnam)
- **Impacts on public budgets:** information not available
- **Creation of jobs:** over 21,000 jobs supported (Austria)
- **Improvements in human health and well-being:** information not available
- **Increased access to energy and reduced fuel poverty:** consumer average energy bill savings of 15 percent (Vietnam)
- **Benefits to energy providers:** increased efficiency and reliability of supply (Austria) and financial savings (Vietnam)

FINANCIAL MECHANISMS

SCOPE OF THE CASES SURVEYED

Financial schemes aimed at facilitating the uptake of more energy efficient technologies by reducing (perceived and actual) financial risks, making the economic case for those technologies, and disseminating both technical and financial information

INSTRUMENT USED

Instrument used. Energy efficiency funds targeting industrial energy users (Thailand and Turkey), and rebates or loans for residential property owners (United States)

BARRIERS TO IMPLEMENTATION

- **Administrative procedures:** burdensome bureaucratic procedures (Thailand) and procedural rules regarding the auditing of the planned interventions (United States) discouraged a more widespread participation at the early stages of implementation
- **Technology costs:** the high cost of certain technologies (Thailand and Turkey) deterred potential investors in those technologies, in spite of the financial support available
- **Monitoring requirements:** the initial investment in measurement equipment required from contractors (United States) resulted in a shortage of contractors during the early stages of implementation
- **Design constraints:** the financing cap for capital-intensive projects (Thailand) prevented a larger uptake among eligible projects
- **Compliance requirements:** lack of penalty for non-compliance may have undermined the credibility of the programmes (Thailand and Turkey)

ENABLERS FOR IMPLEMENTATION

- **Quality assurance:** independent monitoring and reporting of project proposals (Turkey and United States) strengthened the credibility of the programmes
- **Training programmes:** bank staff (Thailand and Turkey) and local businesses (Turkey) were trained in key aspects of cleaner energy finance
- **Communications and branding:** targeted awareness-raising campaigns (Turkey) and the credibility associated with ENERGY STAR (United States) helped raise interest at the initial stages of the programme
- **Ancillary measures:** pilot programmes and the creation of a revolving fund (Thailand) helped stimulate investments at the initial stages of the programme
- **Energy-service companies:** the scheme fostered the development of energy service companies (Thailand), which helped reduce credit and performance risks

BENEFITS

- **Energy savings:** a reduction of 38,200 ktoe (forecast) in 2030, compared to a reference scenario (Thailand), 1.5 TWh per year (Turkey), 23,800 MWh in 2013 (United States)
- **Emission reductions:** between 130 and 140 Mt CO_2 per year (Thailand), 70,500 tonnes of carbon dioxide (United States)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** savings of USD 33.7 billion (forecast) in 2030 (Thailand), savings of USD 108 million in the period 2004-2007 (United States)
- **Impacts on public budgets:** information not available
- **Creation of jobs:** employment creation in peripheral areas (Turkey) and increase in the number of energy efficiency contractors (United States), unquantified in both cases
- **Improvements in human health and well-being:** targeted support for ninety low-income families (United States)
- **Increased access to energy and reduced fuel poverty:** information not available
- **Benefits to energy providers:** enhanced network reliability through reduced load (United States)

INDUSTRY BENCHMARKING

SCOPE OF THE CASES SURVEYED

Reducing energy use in industrial facilities through benchmarking programmes to guide continuous improvements

INSTRUMENT USED

Instrument used. Trading of energy efficiency certificates (India), energy audits combined with various information-sharing initiatives (Malaysia), financial and technical support delivered through local utilities (United States), and tax rebates for energy-intensive industries in exchange for energy-efficiency improvements (Sweden)

BARRIERS TO IMPLEMENTATION

- **Target setting:** the diversity of industries and processes within each industry made it difficult to determine appropriate plant-specific targets (India), and lack of targets reduced the programme's credibility (Sweden)
- **Energy prices:** highly subsidized energy prices prevented the programme from achieving even more substantial results (Malaysia)
- **Programme design:** limited awareness of the benefits of energy efficiency gains (India), lack of coordination among key actors in the programme (United States) and lack of monitoring and evaluation capacity among contractors (United States)
- **Upfront costs:** in spite of the incentives introduced through the programme, companies faced substantial upfront costs which may have deterred potential participants (India)

ENABLERS FOR IMPLEMENTATION

- **Demonstration projects:** enticed companies to engage with the programme (Malaysia)
- **Economies of scale:** companies involved in the programme operate multiple facilities, which allowed for a pooling of resources and experiences (United States)
- **Financial incentives:** a partial risk-guarantee fund and a venture-capital fund helped overcome financial barriers (India)
- **Programme design:** numerous training and effective coordination among key players facilitated the engagement of potential beneficiaries (Malaysia and Sweden)

BENEFITS

- **Energy savings:** energy savings in the period 2012-2015 amounted to USD 16 billion (forecast) in energy savings certificates (India), some 3.2 million GJ per year (Malaysia), net savings amounted to about 1 percent of the facilities' annual electricity consumption (United States), energy savings worth between 0.7 and 1 TWh annually in the period 2005-2009 (Sweden)
- **Emission reductions:** 100 Mt CO_2e in the period 2012-2015 compared to a reference situation (India), 0.1 Mt CO_2 annually or 1.2 Mt CO_2 over a ten-year period (Malaysia)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** potential savings of USD 1 billion in the latest year of operation (India), tax savings amounted to USD 19 million annually (Sweden)
- **Impacts on public budgets:** information not available
- **Creation of jobs:** increased hiring of contractors and consultants (unquantified) with expertise in energy efficiency retrofits (United States)
- **Improvements in human health and well-being:** information not available
- **Increased access to energy and reduced fuel poverty:** information not available
- **Benefits to energy providers:** some participants continued with demand-side management programmes of their own, and utilities in California adopted key aspects of the programme (United States)

INSTITUTIONAL FRAMEWORKS

SCOPE OF THE CASES SURVEYED

Establishing national governance structures and policy frameworks for energy efficiency, and mobilising funding for energy efficiency improvements

INSTRUMENT USED

Financial schemes funded through both domestic and foreign budgets (Mexico and Peru), and action plans and long terms strategies with specific goals (Spain)

BARRIERS TO IMPLEMENTATION

- **Narrow scope:** efforts to improve energy efficiency focused on the supply side, ignoring demand-side management measures (Mexico and Spain)
- **Energy prices:** limited price stimuli (Spain) and lack of measures complementing energy price reform (Mexico)
- **Limited skills:** energy users, government agencies and financiers had little expertise (Peru and Spain), and technical specialists were in short supply (Peru)
- **Institutional coordination:** limited utility involvement prevents a larger uptake of governmental programmes to promote energy efficiency (Peru)
- **Programme structure:** as needs differ with company size and type, programmes have to cater to several types of beneficiaries, but failed to do so (Mexico)

ENABLERS FOR IMPLEMENTATION

- **Awareness levels:** the benefits associated with energy efficiency improvements have been adequately communicated to key stakeholders (Mexico)
- **Financing levels:** domestic and foreign funds were made available to support energy efficiency programmes (Peru)
- **Governance structure:** the agency tasked to promote energy efficiency changed its status, to become financially and operationally independent (Spain)
- **Binding requirements:** European Union requirements drive baseline improvements and encourage improved performance (Spain)

BENEFITS

- **Energy savings:** 3,400 PJ (forecast) in the period 2009-2018 (Peru)
- **Emission reductions:** 0.9 Mt CO_2 in the period 2009-2012 (Peru), and 11.5 Mt CO_2 (forecast) in the period 2011-2020 (Spain)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** USD 94.8 billion savings (forecast) in the period 2012-2040 (Peru), and increase of USD 19 billion in gross value added in 2009 (Spain)
- **Impacts on public budgets:** demand from street lighting reduced by 8 MW in 2012, compared to a reference situation (Peru)
- **Creation of jobs:** 106,400 jobs created in 2009 (Spain)
- **Improvements in human health and well-being:** about 250,000 kerosene cook stoves replaced by liquefied petrol gas cook stoves by 2011, with a target of replacing 1 million (Peru)
- **Increased access to energy and reduced fuel poverty:** replacement of 30,000 inefficient heaters by 2011, with a target of replacing 100,000 (Peru)
- **Benefits to energy providers:** information not available

STANDARDS AND LABELS

SCOPE OF THE CASES SURVEYED

Providing information on energy efficiency and typical annual energy consumption levels, and establishing mandatory minimum energy efficiency requirements for household appliances, as well as industrial equipment and motor vehicles

INSTRUMENT USED

Mandatory product labelling and mandatory minimum energy performance standards (Australia, Fiji and Vietnam)

BARRIERS TO IMPLEMENTATION

- **Label content:** information on operating costs was confused with information on operating savings and even purchase costs (Australia)
- **Limited awareness:** households lacked information about the benefits associated with energy efficiency products (Fiji and Vietnam)
- **Insufficient capacities:** limited policy experience, no experience in negotiating with industry, and lack of testing and accreditation bodies (Vietnam)
- **Market data:** staff limitations hindered necessary data collection efforts (Fiji and Vietnam)
- **Limited funding:** lack of funding constrained the reach of the programme (Fiji)

ENABLERS FOR IMPLEMENTATION

- **Lessons learnt:** building on the programmes in place in Australia and New Zealand helped reduce costs (Fiji and Vietnam)
- **Barrier removal:** a multilateral development aid programme helped remove technical barriers in key technologies (Vietnam)
- **Label design:** careful label design, presenting useful information in a format that is readily understood by consumers (Australia)

BENEFITS

- **Energy savings:** 314 PJ in the period 2000-2013 (Australia), electricity savings equivalent to between USD 153 million and USD 234 million (projected) in the period 2010-2025 (Fiji)
- **Emission reductions:** 86.8 Mt CO_2 in the period 2000-2013 (Australia), 0.6 Mt CO_2 (forecast) in the period 2010-2025 (Fiji)
- **Improvements in air quality:** information not available
- **Macro-economic impacts:** net positive benefit-cost ratio of three, and energy savings worth USD 11.8 billion (2013 prices) in the period 2000-2013 (Australia); positive impacts (unquantified) related to avoided fuel costs (Fiji)
- **Impacts on public budgets:** positive impacts (unquantified) related to reduced electricity use in public lighting systems (Vietnam)
- **Creation of jobs:** information not available
- **Improvements in human health and well-being:** information not available
- **Increased access to energy and reduced fuel poverty:** information not available
- **Benefits to energy providers:** information not available

VOLUNTARY AGREEMENTS

SCOPE OF THE CASES SURVEYED

Improving the efficiency with which manufacturing plants use energy through voluntary programmes agreed between government agencies and sectoral associations

INSTRUMENT USED

Targeted information materials and co-funding for energy efficiency projects (Canada), and standardized sectoral agreements setting out voluntary targets and the means envisaged to achieve them (Chile and Japan)

BARRIERS TO IMPLEMENTATION

- **Lack of experience:** awareness of the benefits of energy efficiency (Canada), and technology supply and costs analyses (Chile) were limited
- **Mutual mistrust:** industries feared inconsistency in policy setting, and government was reluctant to commit funds for small companies with little credit-worthiness (Chile)
- **High standards:** already high efficiency levels limited the scope for additional improvements (Japan)

ENABLERS FOR IMPLEMENTATION

- **Financial support:** incentives in the form of co-funding grants, tax incentives and tax exemptions (Canada)
- **Trade associations:** mediation between government and industry, and negotiation on behalf of their large membership (Chile) made the programme possible
- **Legal requirements:** improvements in energy efficiency are mandatory (Japan)
- **Regulatory inducements:** free energy audits and strong peer pressure against non-compliance (Japan)

BENEFITS

- **Energy savings:** 7.1 percent reduction in 2012, compared to 1999 (Japan)
- **Emission reductions:** 4 Mt CO_2 by a selection of sixteen agreements in the period 2002-2010 (Chile), 5.6 percent reduction in 2012, compared to 1999 (Japan)
- **Improvements in air quality:** a complementary plan to reduce air- and water-borne pollution showed significant achievements in the period 2004-2011 (Japan)
- **Macro-economic impacts:** no information available
- **Impacts on public budgets:** positive impact (unquantified) due to the reduced burden on governmental agencies, associated with avoided energy management planning and regulation (Japan)
- **Creation of jobs:** positive effect (unquantified) in the field of cleaner energy services (Chile)
- **Improvements in human health and well-being:** information not available
- **Increased access to energy and reduced fuel poverty:** information not available
- **Benefits to energy providers:** information not available

TRADE BALANCES

HUMAN HEALTH

LOCAL AIR QUALITY

NETWORK RELIABILITY

ENERGY USE

EMPLOYMENT

GREENHOUSE GAS EMISSIONS

GOVERNMENT EXPENDITURE

AND GROWTH

COMPETITIVENESS

ACCESS TO ENERGY

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